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Science Focus

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STEALTH JUMP JET FIGHTER

The scientist hunting
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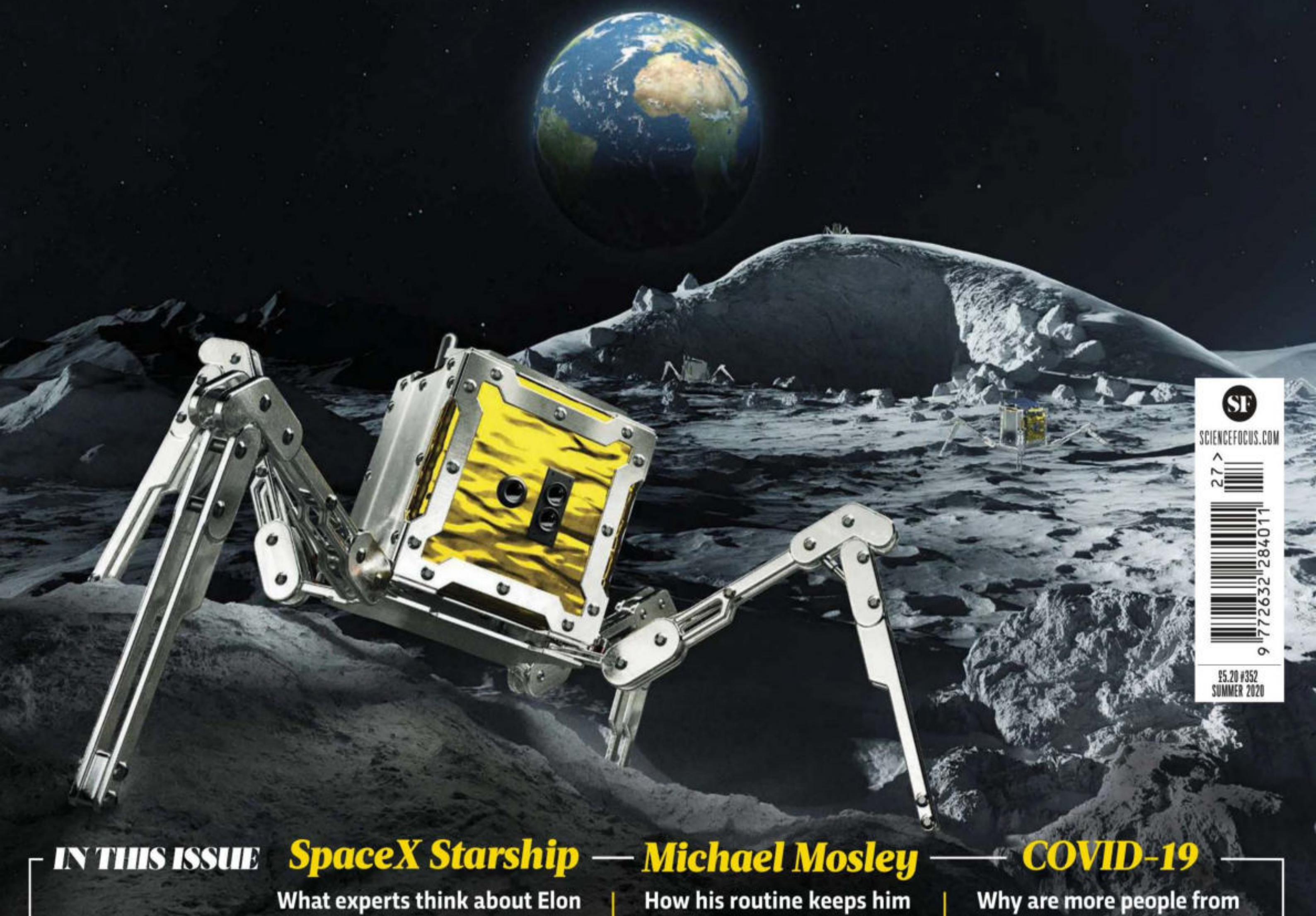

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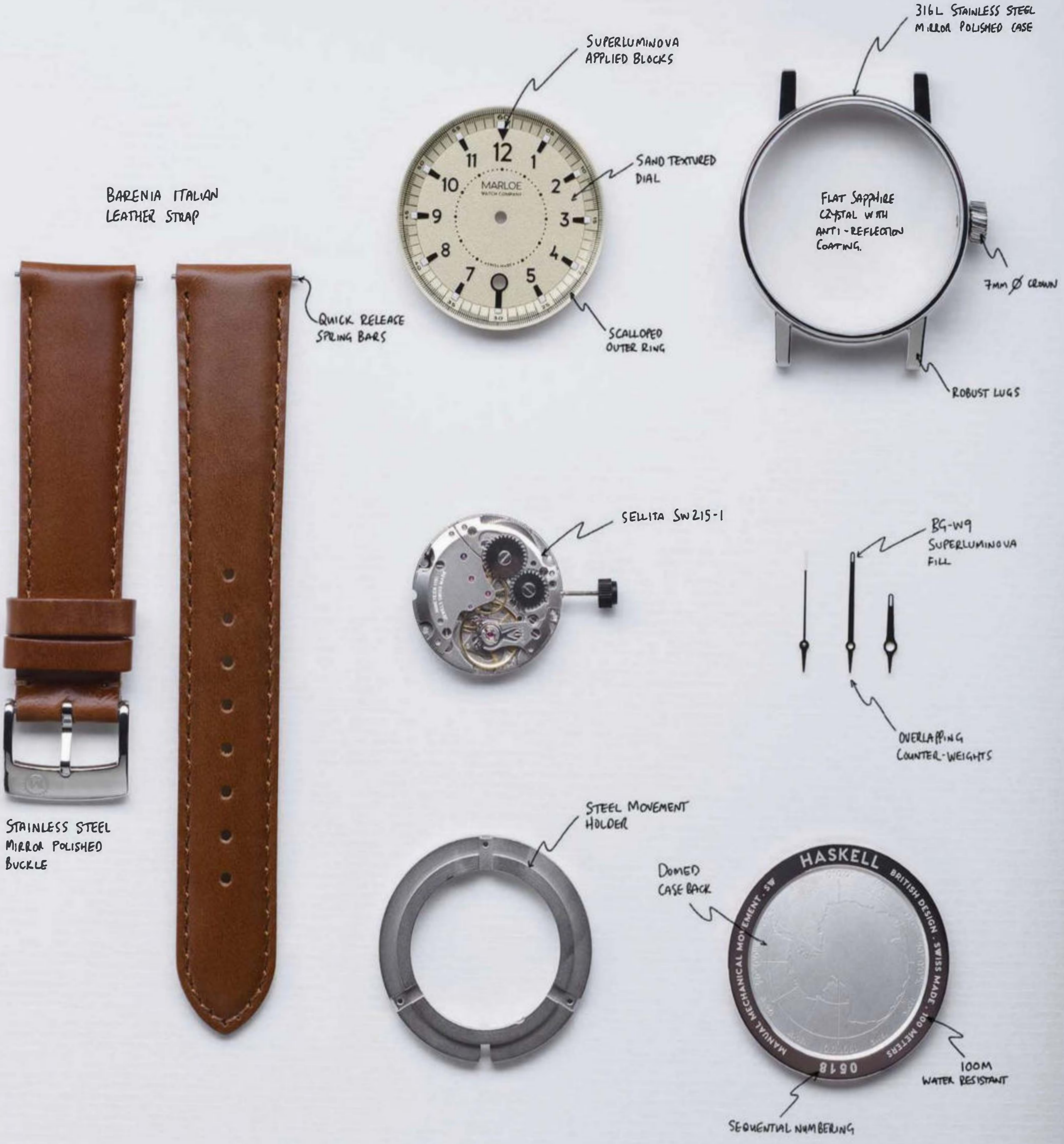
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FROM THE EDITOR

Although lockdown is easing, the world we used to know still seems a long way away. Indeed, as I write this, one city in the UK is seeing its lockdown measures return because its infection rates spiked. And now, three months after we first entered lockdown, I have to admit I might be finding it hard to adjust to this new way of life. I've tried and failed to impose any kind of meaningful routine – besides the nine to five – on my life. My sleep is flaky, my energy levels are waning and my fitness has melted away. And then there's my diet: I visit the fridge so often that I should probably just give in and set up my desk next to it.

Anyway you're not here to hear me moan. It seems I'm not the only one with routine on the mind. By coincidence, this issue both of our columnists, Michael and Aleks (p63 and p64), approach the topic from their own perspectives and reveal the importance of a certain level of routine in your life. Have a read, and maybe try adding some small habits into your day to day if, like me, you're getting a bit fed up. On Michael's advice, I've started going for a walk first thing, to improve my energy levels and sleep. And I reckon it's working.

In the meantime, if you haven't been checking in with us online – you should! We've got the latest news on the COVID-19 pandemic, as well as a brilliant weekly podcast that'll explain the most important ideas in science. We've even started our very own book club that's free to join. Come and find us at **sciencefocus.com**

Enjoy!

Daniel Bennett

Daniel Bennett, Editor

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JUANITA BAWAGAN

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DR CHRISTIAN JARRETT

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The first of a 10-part series telling the story of how public and media perceptions of climate change were influenced by big name oil companies.

BBC Radio 4
Mondays at 1:45pm, starting 27 July

Led By The Science

This documentary speaks to scientists and politicians about the decisions made since the coronavirus pandemic began, and how they have affected the general public's opinion of science.

BBC Radio 4
27 July, 8pm

A Wild Year

Using time-lapse filmography, *A Wild Year* shares the beauty of all four seasons across iconic regions of the British countryside: the Pembrokeshire Coast, the North York Moors and the Fens.

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BBC Science Focus (ISSN 0966-4270) (USPS 015-160) is published 14 times a year (monthly with a Summer issue in July and a New Year issue in December) by Immediate Media Company, Bristol, Eagle House, Colston Avenue, Bristol, BS1 4ST. Distributed in the US by Circulation Specialists, LLC, 2 Corporate Drive, Suite 945, Shelton, CT 06484-6238. Periodicals postage paid at Shelton, CT and additional mailing offices. POSTMASTER: Send address changes to *BBC Science Focus*, PO Box 37495, Boone, IA 50037-0495

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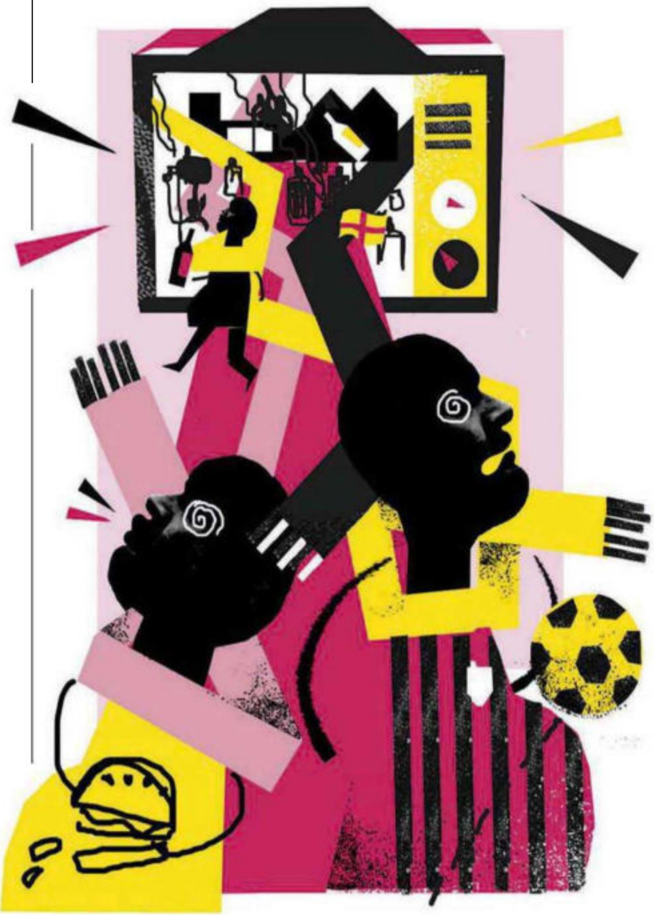
WHAT POP PSYCHOLOGY GETS WRONG



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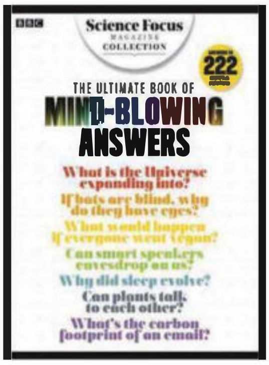
SPECIAL ISSUE



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THE ULTIMATE BOOK OF MIND-BLOWING ANSWERS

What is the Universe expanding into?
If bats are blind, why do they have eyes?
What would happen if everyone went vegan?
Can smart speakers eavesdrop on us?
Why did sleep evolve?
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What's the carbon footprint of an email?

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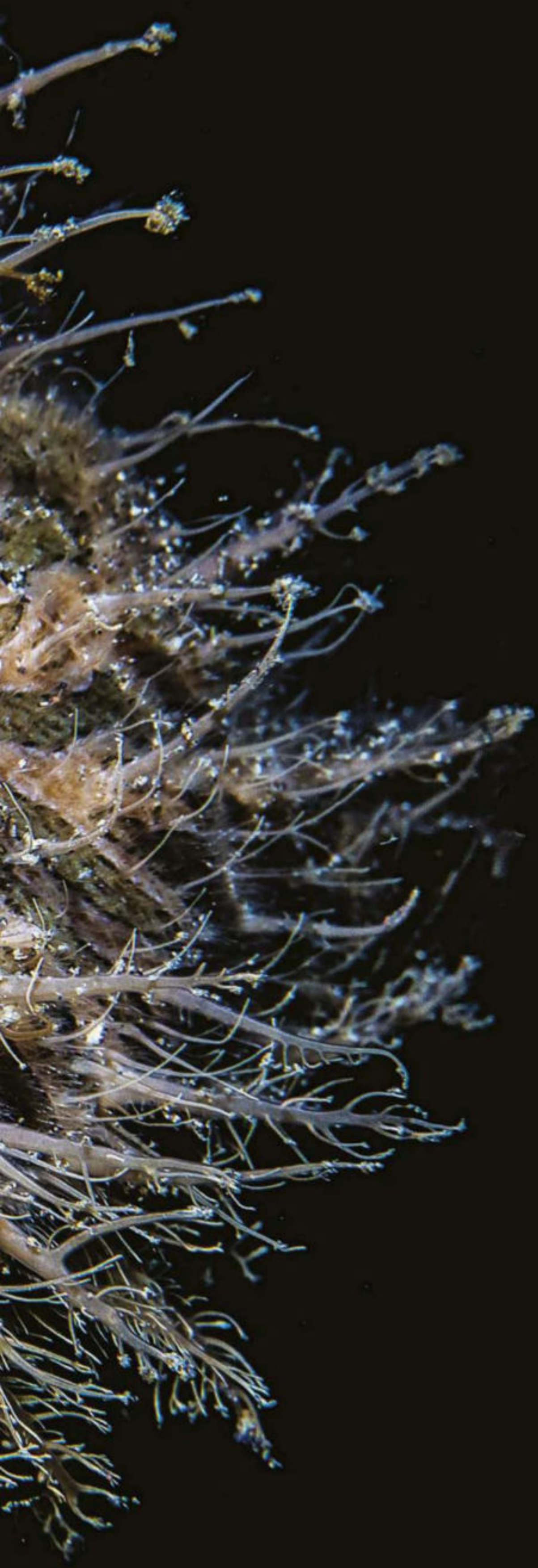

EYE OPENER

In need of a comb

LEMBEH, INDONESIA

This unusual-looking fish is called a striated frogfish (*Antennarius striatus*), due to its stripy exterior, but it's also known as the hairy frogfish. In fact, the 'hairs' that cover the fish are actually small spinules – semi-flexible, thorn-like spikes. The fish only grows to a little over 20cm in length, but is capable of consuming prey that's as big as itself.

To catch that prey, the hairy frogfish uses a modified dorsal fin on its forehead, called an illicium. At its tip is a lure, which mimics a worm and acts as bait to draw the prey towards the frogfish's mouth.

The hairy frogfish lives on coral reefs in the Indian, Pacific and Atlantic Oceans and is able to change its colour to blend into its surroundings. But with ocean temperatures rising and pH levels dropping, the hairy frogfish's habitat is at risk of coral bleaching. As the coral loses its colour, the frogfish must also become paler so that it remains camouflaged.

NADIA ALY

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EYE OPENER

Under a bell jar

PARIS, FRANCE

In June, restaurants and bars in France opened for the first time in nearly three months. Around the corner from the Louvre Museum in Paris, the H.A.N.D restaurant welcomed diners with food, drink and these new pieces of decor.

The PLEX'EAT protective 'bubble' was created by French designer Christophe Gernigon to help prevent the spread of COVID-19. By sitting under the bubble, customers protect not only themselves, but also other diners and waiting staff too.

"When I saw proposals to place Plexiglas dividers on restaurant tables, it gave me the impression of being in a prison visiting room," says Gernigon. "I told myself that I had to imagine a more beautiful, attractive object. Even if we don't want to remain indefinitely under a bell jar, the PLEX'EAT protective bubbles let restaurants open rapidly in total security."

EYEVINE

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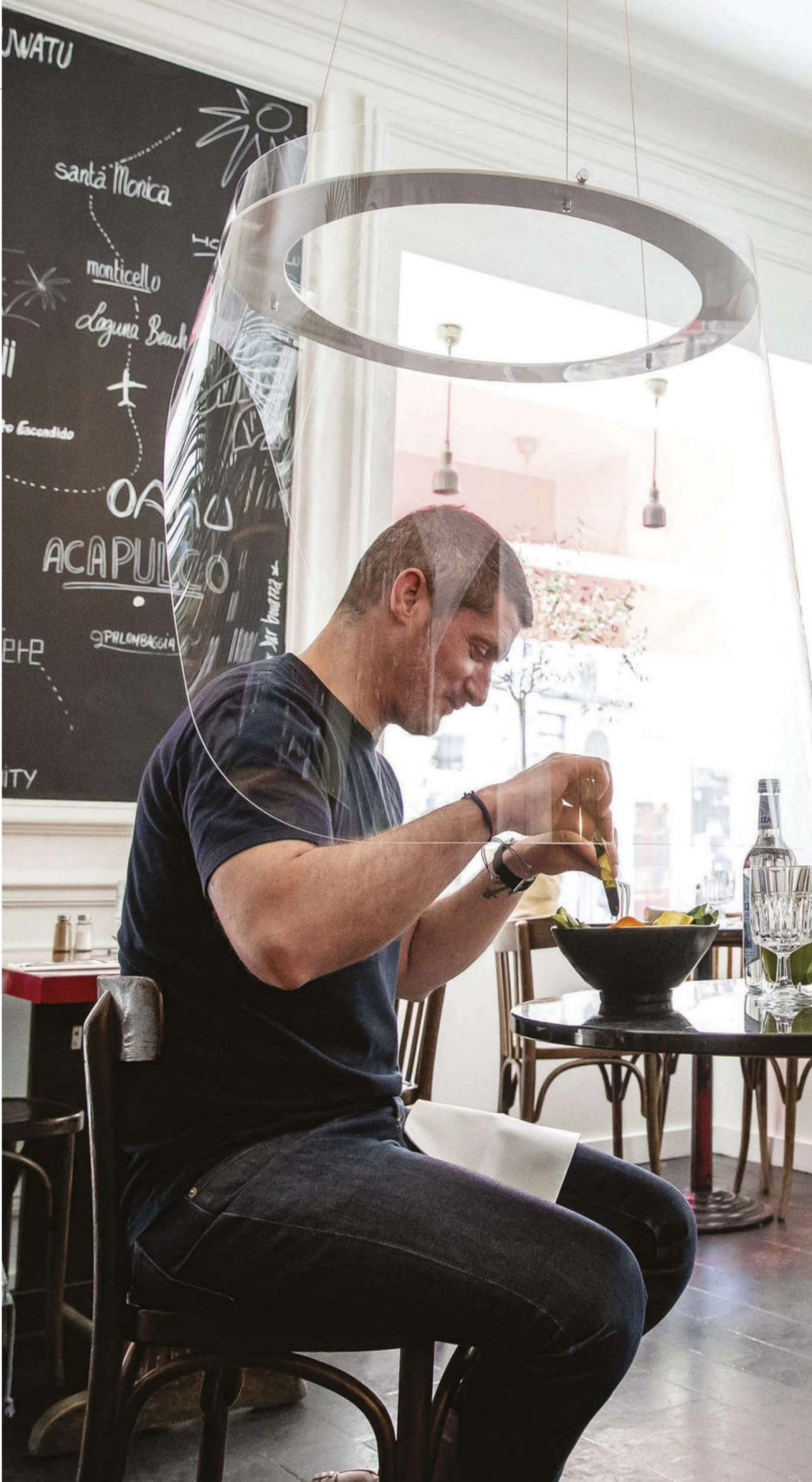

CONVERSATION

YOUR OPINIONS ON SCIENCE, TECHNOLOGY AND *BBC SCIENCE FOCUS*

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LETTER OF THE MONTH

Love to learn

In reply to 'A learning curve' by Aleks Krotoski (May, p62) I think parents can often underestimate the impact they already have on their children's education and general upbringing in everyday life. Just because there's no school for children to go to at the moment, it doesn't mean they're going to become complete monsters. That being said, it's understandable for parents to feel like they now have a vastly increased workload to handle.

It's fair that parents are feeling pressure at the moment, but they should also remember that children can have a fascination in any number of things and so, whatever decision the parents do make, it's likely to have a positive impact.

Gwilym Jones, *age 17*

WRITE IN AND WIN!

The writer of next issue's *Letter Of The Month* wins a **TomTom GoPremium sat-nav**. This sat-nav device gives you trusted road and traffic guidance, helps you avoid traffic jams, and even lets you pick attractions and scenic routes for an inspiring road trip. Plus, you can share your location, notifications and ETA with loved ones, so you can keep your mobile safely in your pocket. **tomtom.com**

In the name of science

Reading the news story about a leg being transplanted onto a rat (April, p14), I find it disturbing to think that researchers still think it's okay to remove and replace limbs from innocent animals all in the name of science. Humans are not superior to other animals. Just because we can, doesn't mean we should.

Shannon Ripsher

No easy answer

The article by Colin Barras on the carbon cost of eating meat vs vegan lifestyles (April, p62) was thought-provoking, especially the comparisons between different food sources. But there is a problem in converting pasture for growing crops. I live in Scotland, where much of the land is totally unsuitable for growing crops. Even trees find it difficult to take root in many areas. However, we do have huge numbers of cattle that produce milk as well as beef, and sheep that produce wool as well as mutton. Farmers here rely on their animals to provide their income.

There is no simple answer to the problem of the greenhouse effect, but any solution must take into account the people and lives being affected by any arbitrary changes to farming practice.

Kathy Turner

> "THIS IS ACTUALLY ONE REASON WHY REPRESENTATION IS SO IMPORTANT IN STEM. WHEN PEOPLE GET INTO A FIELD THAT'S BEEN RUN PREDOMINANTLY BY WHITE MEN, THEY WANT TO SEE SOMEONE THAT LOOKS LIKE THEM"
>
> MICHÉ AARON, p66

If only they wore sunglasses

The *Q&A* section of your June issue mentioned a study in the Czech Republic and Germany (p82) that reported that dogs tend to poo aligning themselves with the north-south axis of the Earth's magnetic field. I have my own theory. They poo facing north to avoid having the Sun in their eyes while going about their business and because they feel safer being able to see any approaching predators, from at least one direction anyway. If researchers in the southern hemisphere had the time to do a similar study, I suspect they might find dogs aligned themselves with the Earth's magnetic field but facing south.

Ken Evans, *Shrewsbury*

Silver lining

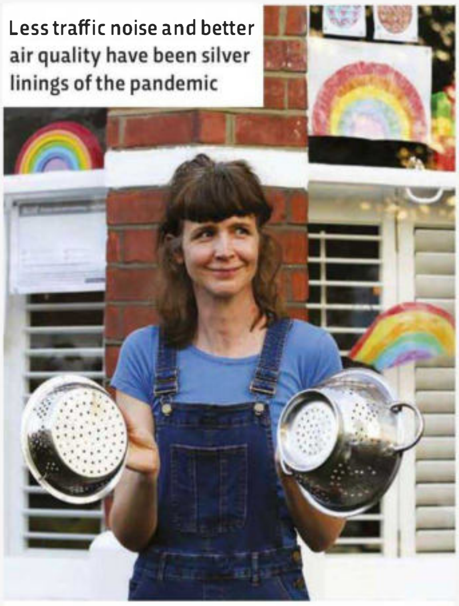
I am the first to applaud the courage of our NHS staff who risk their lives to save ours. Every Thursday has become iconic of this gesture. My heart goes out to all those who have lost loved ones to (what Boris Johnson described as) the "invisible mugger". However, the media seems to have forgotten the important silver lining of the changes in the environment for the better, like clearer sky at night, the dawn chorus sounds louder, and of course pollutants are down. This is something to celebrate.

Francisco Mesa, *Cornwall*

It has indeed been nice to hear the sounds of birds where there was once the sound of cars. And, with regards to climate change, there have been a number of different analyses that show emissions this year will fall by 4-8 per cent, somewhere between two and three billion tonnes. But it's important to note that we've still got a way to go before we get to net zero emissions, as laid out by the Paris Climate Agreement.

There are some other areas of science where lockdown has provided researchers with an unexpected opportunity – you can read a piece on this very subject on our website: **bit.ly/lockdown-research**

Amy Barrett, *editorial assistant*
BBC Science Focus



Less traffic noise and better air quality have been silver linings of the pandemic

GETTY IMAGES X3

Oops...

In your May 2020 issue, I read the phrase "Nothing phases them" ('A learning curve', p62). Really? At first I thought it was going to be some clever homophone joke, or about phase shifting but no, that was the actual phrase. Just in case you have no idea what I'm on about, the word is 'fazes'.

Jeremy Child

All right, all right, our hands are up, Jeremy! We're currently working remotely from home, without the ability to check proofs as well as we could in the office. Of course the correct word should have been 'fazes'. We can only blame our mistake on the lack of an office biscuit tin to fuel us when the blood sugar levels drop.

Alice Lipscombe-Southwell, *managing editor*
BBC Science Focus

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ANNUAL SUBSCRIPTION RATES (INC P&P):
UK/BFPO £72.80; Europe & Eire £77.80; Rest of World £82.80

Audit Bureau of Circulations
44,687 (combined, Jan-Dec 2019)

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Ever noticed how sometimes it seems that everybody is shouting, but no one is listening?

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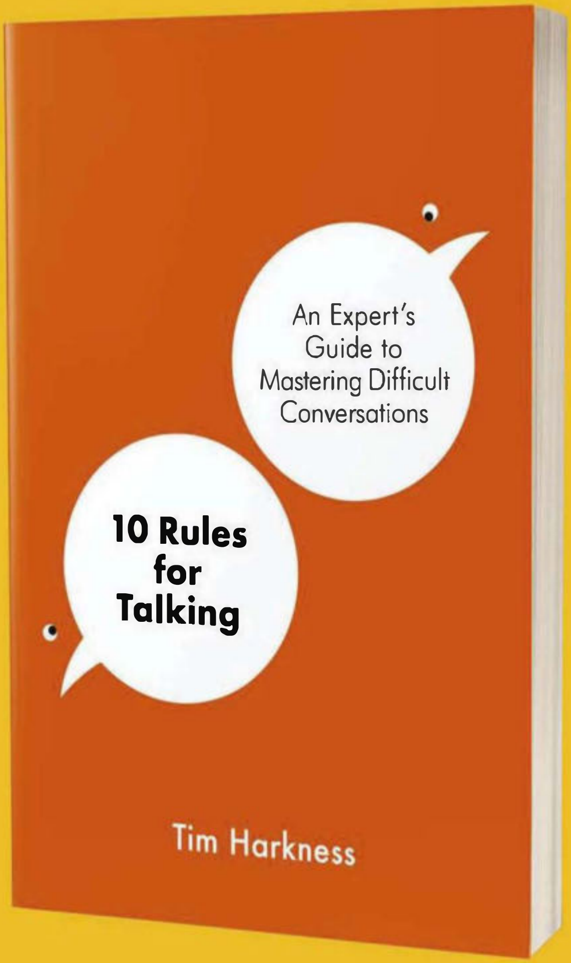
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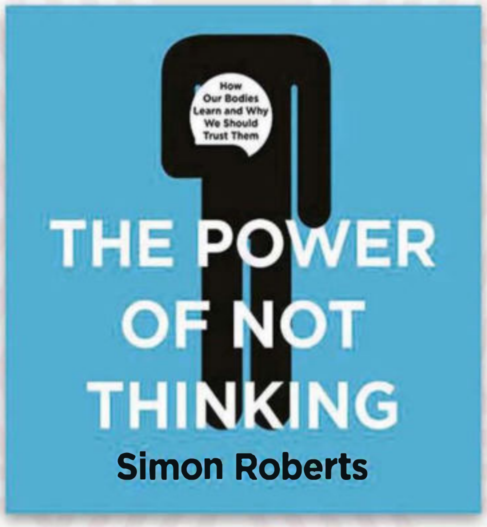
How Our Bodies Learn and Why We Should Trust Them
THE POWER OF NOT THINKING
Simon Roberts

Humans are capable of far more than we are currently led to believe.

We just have to stop thinking and start trusting our bodies.

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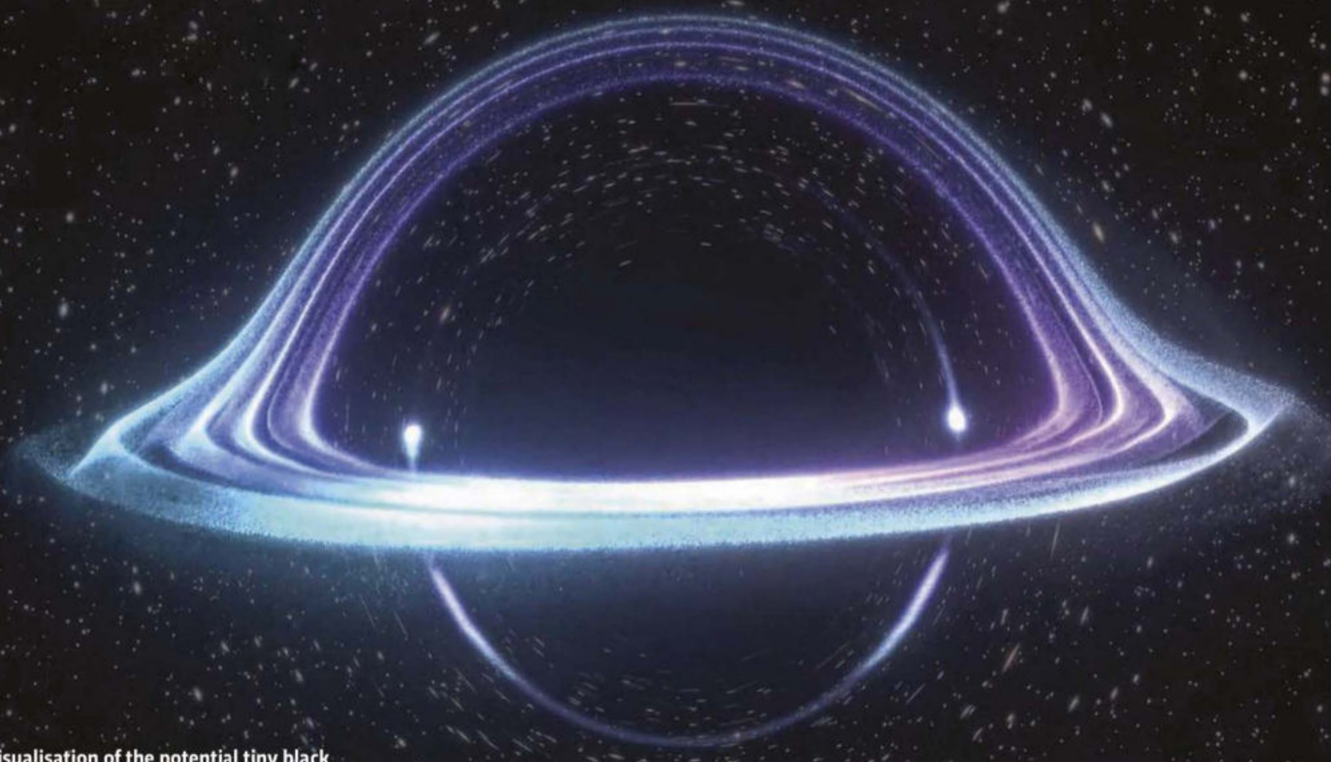
A CHANGE OF TUNE Birds take their songs to new areas after wildfires p18

TOUGH CRITICS Primates dislike accurate cartoons of themselves p19

DISCOVERIES

MYSTERIOUS OBJECT MAY BE LIGHTEST BLACK HOLE EVER FOUND

Gravitational waves point towards a never-before-seen object located 800 million light-years away



Visualisation of the potential tiny black hole colliding with a larger object and sending out gravitational waves

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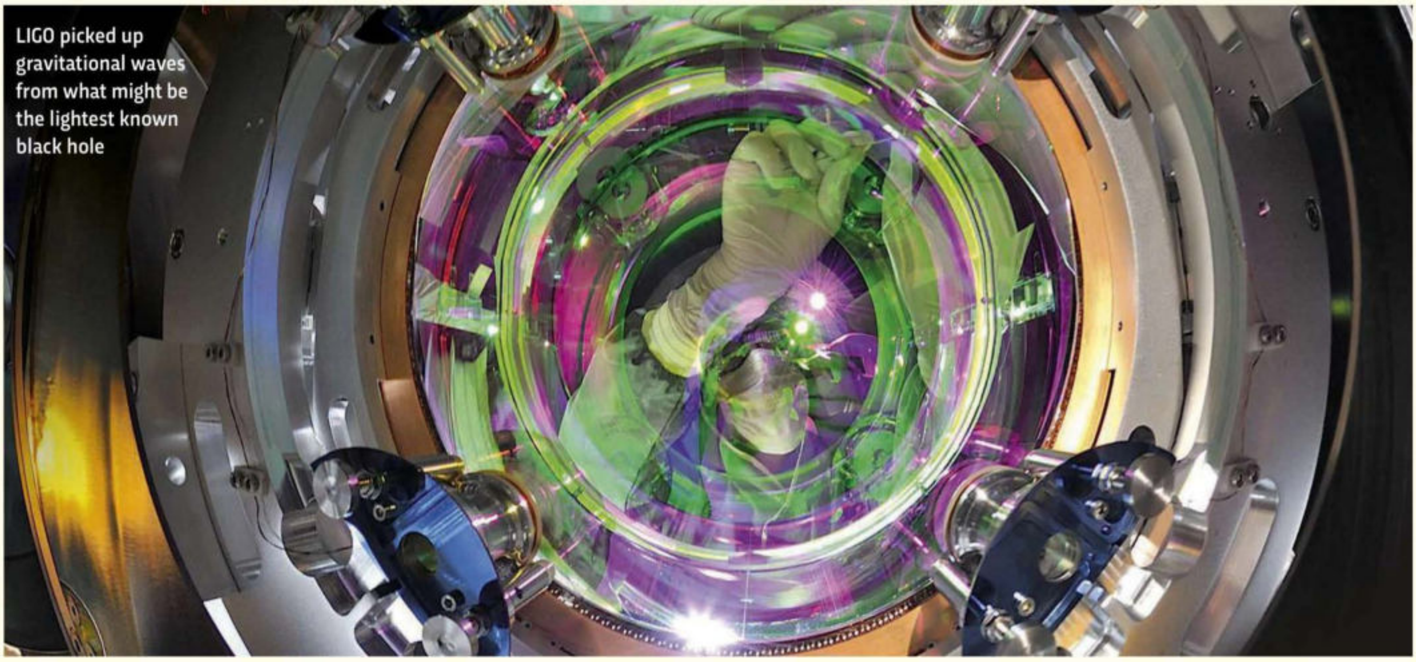
Sleep together Sharing a bed improves your chances of a better snooze p20 **Where's your head at?** Survey sheds light on people's experiences of exploding head syndrome p21 **Fasten seatbelts for blast off!** Laying the foundations for private space travel p24

News in brief

EMOTIONAL SENSITIVITY IS PARTLY IN OUR GENES

Some people take things to heart, while others appear impervious to criticism. A study carried at Queen Mary University of London on twins has revealed that 47 per cent of the differences in sensitivity comes from our genes, with the rest coming from environmental factors during childhood.

"Sensitivity is something we all share as a basic human trait," said study leader Prof Michael Pluess. "But we also differ in how much of an impact our experiences have on us. Scientists have always thought there was a genetic basis for sensitivity, but this is the first time we've been able to actually quantify how much of these differences in sensitivity are explained by genetic factors."



LIGO picked up gravitational waves from what might be the lightest known black hole

Astronomers have spotted what might be the lowest mass black hole ever found. Believed to be 2.6 times the mass of the Sun, the object was detected on 14 August 2019 by scientists at the Laser Interferometer Gravitational-wave Observatory (LIGO) in the US and the Virgo interferometer in Italy.

Black holes form when the largest stars go supernova and their cores collapse under their own gravity. Until now, the lightest known black hole was five solar masses (our Sun = one solar mass).

The object may turn out not to be a black hole. But even so, its discovery is still significant because it falls squarely into the 'mass gap', the unexplained interval between the lightest known black holes and heaviest neutron stars.

"The mass gap has been an interesting puzzle for decades and now we've detected an object that fits inside it," said Dr Pedro Marronetti, of the US's National Science Foundation, which funds LIGO. "That can't be explained without defying our understanding of extremely dense matter or what we know about the evolution of stars."

> "It left the scientists scratching their heads as to the identity of the object"

Neutron stars are the remnants of stars that aren't quite big enough to form black holes. They are tiny, typically less than 20 kilometres wide, but extremely dense; the heaviest known neutron star is 2.5 solar masses.

"We don't know if this object is the heaviest known neutron star or the lightest known black hole, but either way it breaks a record," said Prof Vicky Kalogera, one of the authors of the report announcing the discovery.

The record-breaking object was detected by the gravitational waves produced when it merged with another much larger object, estimated to be 23 solar masses, in an astronomical event designated GW190814. The waves rippled across 800 million light-years of space before they reached Earth and left the scientists that picked them up scratching their heads as to the identity of the object.

There are a few reasons for the uncertainty. First, it could simply be that the merger took place too far away for light from it to be easily observed.

Alternatively, the smaller object could be a neutron star – though it would have to be bigger than the current theory of neutron star formation would allow. If so, Kalogera thinks that the neutron star could have been swallowed whole and not torn apart, since the other object in the collision was so much larger. "I think of Pac-Man eating a little dot," said Kalogera. "When the masses are highly asymmetric, the smaller neutron star can be eaten in one bite." The result would be a collision that gives off no light, only gravitational waves.

Or, if it was a collision between two black holes, it's unlikely the event would have given off any light but it would make the 2.6-solar-mass object the lightest black hole ever discovered.

ALTRUISTS

Doing good does you good. Volunteers who help out for at least 100 hours a year live longer, healthier lives, a study of 13,000 adults carried out at Stanford University has found. "Humans are social creatures by nature. Perhaps this is why our minds and bodies are rewarded when we give to others," said lead researcher Dr Eric Kim.

MODEST PEOPLE

People who rate more highly on tests for modesty are also more likely to be happy and are less prone to depression, a study carried out at Peking University has found.

Good month

Bad month

FOOTBALL FANS

More than 20 of the 92 professional English Football League clubs could face flooding in their stadiums by 2050 due to climate change, a study commissioned by the Rapid Transition Alliance has found. And we thought there was enough diving already.

LATE EATERS

Eating dinner later in the evening may cause us to pile on the pounds, researchers at Johns Hopkins University have found. They found that people who ate at 10pm had higher blood sugar levels and that they burned less ingested fat than those that ate at 6pm.

LIGO, GETTY IMAGES, RICHARD GRAINGER/UNIVERSITY OF SYDNEY ILLUSTRATIONS: CATHAL DUANE

Judging by their diet, it seems great whites rarely hunt at the surface

MARINE BIOLOGY

A fin above water isn't a shark on the hunt

A more scientific opening scene to the movie *Jaws* would look wildly different, as recent research has shown great white sharks spend more time feeding close to the seabed than previously thought.

"The stereotype of a shark's dorsal fin above the surface as it hunts is probably not a very accurate picture," said University of Sydney PhD candidate and lead author of the study, Richard Grainger.

Grainger and his team are the first to run a study of this aspect of the dietary habits of great white sharks. By looking at the stomach contents of 40 young great white sharks, the researchers were able to identify different types of prey and, knowing the habitats of the prey, could pinpoint where the sharks spent most of their time hunting.

"White sharks have a varied diet," said Dr Gabriel Machovsky-Capuska, a co-author of the study. "As well as east Australian salmon, we found evidence of other bony fish including eels, whiting, mullet and wrasses. We found that rays were also an important dietary component, including small bottom-dwelling stingrays and electric rays."

The only mammal found in the sharks' stomachs was dolphin. It's likely that the hunting of bigger prey, including other sharks, would not happen until the great white sharks have grown to 2.2 metres long, explains Grainger. The research also showed that the larger the shark, the higher the fat content in their diet.

To review the great white sharks' diets, the researchers had to collect stomachs from deceased animals. These were caught in the New South Wales Shark Meshing Program, which is designed to prevent interactions between humans and sharks on 51 Australian beaches.

The results of the study will help in the protection of the species, as well as in managing its relationship with humans.

SEA SNAIL VENOM COULD HELP TREAT DIABETES

A new form of insulin, inspired by venomous sea snails, could offer better treatments for diabetics. The hormone insulin was discovered nearly 100 years ago and in humans, it helps regulate blood sugar. But some predatory cone snails use it as a weapon, releasing it into the water to cause their prey's blood glucose levels to plummet, paralysing them for long enough for the snail to make the kill. Scientists from the University of Utah have now combined the effectiveness of human insulin with the fast-acting potential of the snail insulin to develop a better, hybrid version of the hormone, which they call 'mini-insulin'.

In numbers

415.5 PETAFLOPS

The processing power of Japan's new Fugaku supercomputer – around two million times more powerful than a modern laptop.

36

The most likely number of contactable alien civilisations in the Universe – as estimated by researchers at the University of Nottingham.

16 ATOMS

The size of a motor constructed by Swiss researchers – the smallest ever made.

ARCHAEOLOGY

Miniature bird is the oldest Chinese work of art

Over 13,000 years ago, an artist used a range of techniques to delicately carve this miniature bird out of a piece of burnt bone. Unearthed by archaeologists in Lingjing, China, the carving is the oldest Chinese work of art ever found.

Humans have been creating sculptures since the Upper Palaeolithic (50,000 to 12,000 years ago). The earliest are carved from mammoth tusk and date back 35,000-40,000 years. Found in German caves, these record-setting examples include a lion-headed human and a Venus figurine, and provide early evidence of 'symbolic thought' – the ability to represent objects and ideas physically through art or ritual.

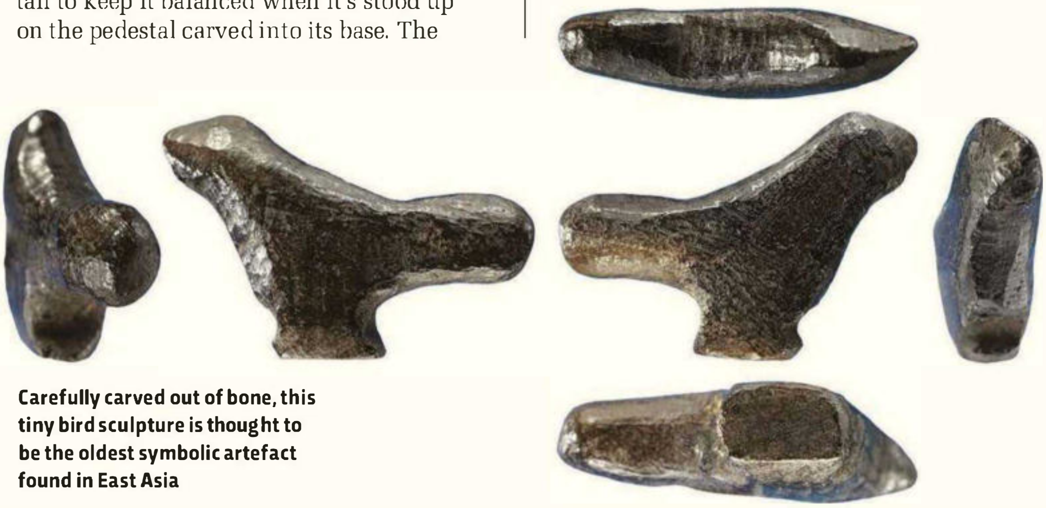
Now, this bird figurine shows that sculpture was emerging independently in East Asia during the same period.

The bird sculpture was discovered by a team of archaeologists led by Prof Francesco d'Errico at the University of Bordeaux, France. The artefact is just two centimetres long and incredibly well-preserved. It has a short neck and rounded bill, but an oversized tail to keep it balanced when it's stood up on the pedestal carved into its base. The sculpture is thought to represent a 'passerine' – a diverse group of birds that perch with an upright posture on feet with three toes facing forwards and one facing backwards.

The researchers analysed the sculpture using microscopy and X-ray scanning, determining that it was carved from a mammal limb bone that had been blackened by heating. They also painstakingly reconstructed the sculpting process: the bird was created using four different techniques: gouging, abrading, scraping and incising.

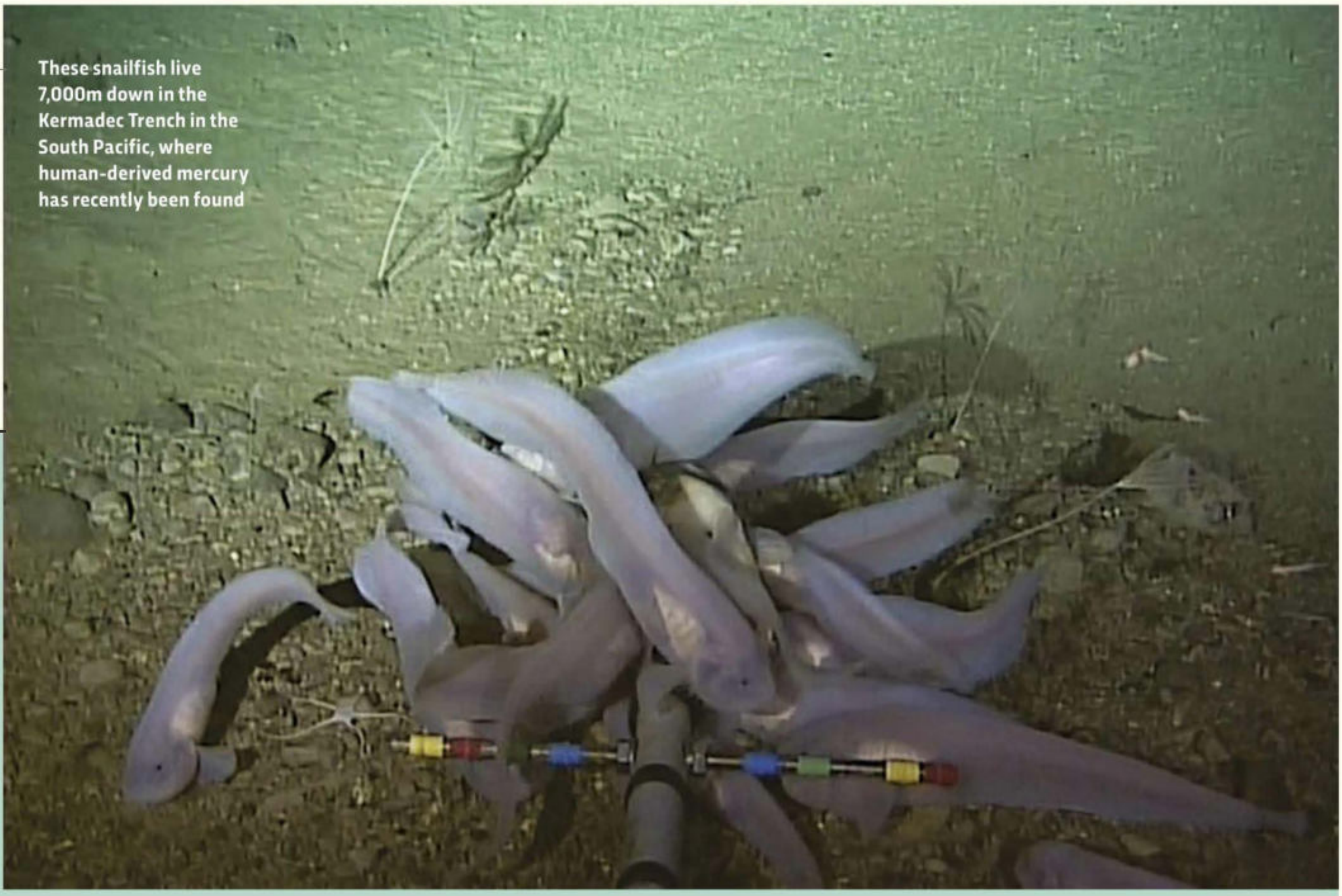
"Our analysis reveals that the Lingjing artist has chosen the appropriate techniques and applied them skilfully to faithfully reproduce the distinct anatomical features of a passerine," the researchers wrote. "The style of this diminutive representation is original and remarkably different from all other known Palaeolithic avian figurines."

The researchers estimate the figurine to be 13,500 years old – more than 8,500 years older than other animal sculptures that have been found in East Asia.



Carefully carved out of bone, this tiny bird sculpture is thought to be the oldest symbolic artefact found in East Asia

ALAMY, FRANCESCO D'ERRICO/LUC DOYON, ALAN JAMIESON



These snailfish live 7,000m down in the Kermadec Trench in the South Pacific, where human-derived mercury has recently been found

ENVIRONMENT

Toxic mercury pollution found in the deepest trenches of the ocean

The impact of heavy industry reaches even the remotest parts of the planet

Human-derived mercury is a serious threat to the marine world and now appears to have infiltrated the deepest, remotest parts of the ocean.

Mercury is a naturally occurring element that can be introduced to the environment through volcanic eruptions and forest fires. Human-derived mercury, however, comes from industrial activity, incineration, mining and energy generation. It boosts the amount of airborne mercury, which finds its way into rivers and oceans where it enters the food chain and accumulates in marine animals, with larger predators such as swordfish and sharks containing particularly high quantities.

Mercury is toxic to humans and other animals, and can lead to birth defects and neurological problems.

Now, two independent teams of scientists have found methylmercury, a more toxic form of mercury, present in fish and crustaceans captured in some of the deepest ocean trenches, including the 11,000m-deep Mariana Trench.

"This is a surprise," said Dr Ruoyu Sun, from Tianjin University, China. "Previous research had concluded that methylmercury was mostly produced in the top few hundred metres of the ocean. This would have limited mercury bioaccumulation by ensuring that fish which forage deeper than this would have had limited opportunity to ingest it. With this work, we now believe that isn't true."

> "The researchers concluded that the methylmercury was not produced naturally in the deep-sea environment"

The researchers concluded that the methylmercury found within the creatures was not produced naturally in the deep-sea environment and that much of it is likely to have come from human activity.

"We know that this mercury is deposited from the atmosphere to the surface ocean and is then transported to the deep ocean in the sinking carcasses of fish and marine mammals, as well as in small particles," said Dr Joel Blum, a geochemist from the University of Michigan.

This research demonstrates the far-reaching impact that human activity can have on even the remotest environments and will lead to greater understanding about how mercury affects the marine world.

WILDFIRES CAN DIVERSIFY BIRD SONG

Low-intensity wildfires cause birds to flee to new areas, increasing the diversity of bird song within a forest, according to researchers in California.

The team recorded the mating songs of over 1,500 hermit warblers – small grey and yellow birds that breed on the western coast of the US. The birds occupy many different types of forest and have developed 35 dialects. "The birds were generally isolated from each other," said Dr Brett Furnas, lead author of the paper. "It's a bit like how Darwin's finches on the Galápagos became different, but of course I am talking about song here, a cultural trait which might happen quicker than with genetics."

The researchers found that after an area is hit by a low-intensity wildfire, it is recolonised by new hermit warblers. These bring their dialect with them, increasing the song diversity.

ANTHROPOLOGY

48,000-year-old arrowheads found in Sri Lankan cave

An international team of researchers have found a cache of immaculately preserved bone arrowheads in the cave of Fa-Hien Lena, deep in the heart of Sri Lanka's rainforest. The find is evidence of the earliest use of bows and arrows anywhere outside of Africa, they said.

The team, made up of researchers from the Max Planck Institute for the Science of Human History (MPI-SHH) in Germany, Griffith University in Australia, and the Sri Lankan government's department of archaeology, said the bone arrowheads are around 48,000 years old and were probably used to hunt rainforest prey such as monkeys and squirrels.

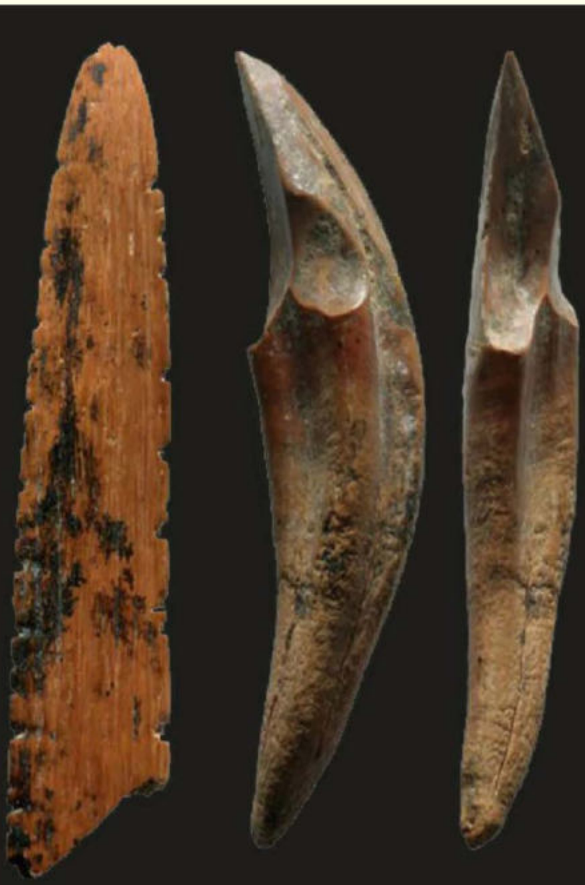
"The fractures on the points indicate damage through high-powered impact – something usually seen in the use of bow-and-arrow hunting of animals," said lead author Dr Michelle Langley of Griffith University. "This evidence is earlier than similar findings in Southeast Asia [from] 32,000 years ago and is currently the earliest clear evidence for bow-and-arrow use beyond the African continent."

The arrowheads were found alongside a host of other tools that may have been used for fishing and fibre-working, along with other decorative items. Together, the finds point to the development of a complex, early human social network in the tropics of South Asia.

"We also found clear evidence for the production of coloured beads from mineral ochre and the refined making of shell beads traded from the coast, at a similar age to other 'social signalling' materials found in Eurasia and Southeast Asia, roughly 45,000 years ago," said Langley.

According to the researchers, the findings highlight the fact that archaeologists can no longer link specific technological, symbolic, or cultural developments in early humans to a single region or a particular environment.

"Humans at this time show extraordinary resourcefulness and the ability to exploit a range of new environments," said co-author and director at the MPI-SHH Nicole Boivin. "These skills enabled them to colonise nearly all of the planet's continents by about 10,000 years ago, setting us clearly on the path to being the global species we are today."



Arrowheads discovered in Sri Lanka's Fa-Hien Lena caves are the oldest ones to be found outside Africa

BBC TWO

Watch a clip of Pacific leaping blennies from *Blue Planet II* bit.ly/leaping_blenny

Pacific leaping blennies live on tropical island reefs in the southern and central Pacific. Their adult lives are spent out of water, jumping around rocks in the splash zone

EVOLUTION

Like a fish out of water

We know that life began in the water, but now a remarkable group of fish have given scientists new clues about how vertebrates made the leap onto land.

There are more than 900 species of blennies; they are an incredibly diverse group of fish, occupying a wide range of habitats. Some species are fully aquatic, while others live in the intertidal zone – the region of the seashore that's underwater at high tide and out of water at low tide – where they deal with wide fluctuations in temperature and salinity. Some blennies can even remain out of water for hours at a time, as long as they stay moist. This diversity makes them really useful animals to study when investigating how animals moved from water to land. A flexible diet and behaviour is key to making the initial transition, according to researchers from the University of New South Wales and the University of Minnesota.

"Fossils can give us important insights into how that transition might have unfolded, and the types of evolutionary adaptations it required or produced," said lead author Dr Terry Ord. "But having a contemporary example of fish making similar ecological transitions can also help us understand the general challenges that are faced by fish out of the water."

The scientists think that once fish make the leap to living on land, restrictions in the types of food available mean that their diet and behaviour then become more specialised. For example, land-dwelling blennies have become adapted to scraping algae off rocks with their teeth.

"Terrestrial blennies are really agile out of water, and I suspect they've adapted their body shape to allow them to hop about the rocks so freely. Which in turn implies they might not be able to go back to the water," said Ord. "It would also be exciting to know how their sensory systems might have adapted out of the water as well, given vision and smell would probably work quite differently in these environments."

LANGELY ET AL, GETTY IMAGES, TERRY ORD ILLUSTRATIONS: OVADIA BENISHU

They did what?

Monkeys shown animations

WHAT DID THEY DO?

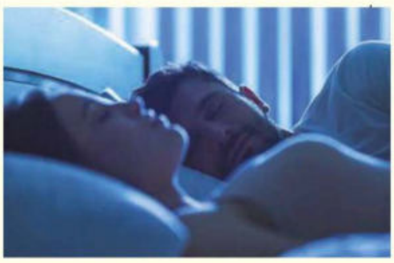
Researchers from the Society for Neuroscience in Washington, DC, showed a group of rhesus macaque monkeys a series of animations featuring monkeys rendered in varying degrees of detail.

WHY DID THEY DO THAT?

In robotics, the term 'uncanny valley effect' is used to describe the revulsion and feelings of unease that arise when we are confronted by a robot or a computer-generated figure that appears to be almost, but not quite, human. The effect is also seen in monkeys, which makes studying their social behaviour using animated monkey faces particularly difficult.

WHAT DID THEY FIND?

The monkeys were unconcerned when confronted with wire-frame avatars, but avoided looking at greyscale or furless ones, indicating the existence of the uncanny valley effect. However, the monkeys were comfortable when shown a highly detailed furred monkey avatar, and behaved towards it comparably to a real monkey.



COUPLES THAT SLEEP TOGETHER SLEEP BETTER

This may come as a surprise to those of us with partners that snore, but sharing your bed with a loved one can help you to sleep better, a study at the Center for Integrative Psychiatry in Germany has found. The team monitored the sleep of 12 young, healthy, heterosexual couples who spent four nights in the sleep lab. They found that sleeping with a partner increased the participants rapid eye movement (REM) sleep – a mode of sleep associated with improved emotion regulation, memory consolidation, social interactions and creative problem solving.

MEDICINE

Rice is nice, but if it can reduce blood pressure then all the better

Genetically modified rice could one day help keep your blood pressure down

Researchers have lowered rats' blood pressure by feeding them rice harvested from a plant genetically edited to produce medicine known to reduce hypertension. High blood pressure is a major risk factor for heart disease and stroke. Medication for the condition, known as angiotensin-converting-enzyme (ACE) inhibitors, comes with a long list of potential side effects, including dry cough, headaches, rashes and kidney impairment. But the research, published in the *Journal Of Agricultural And Food Chemistry* noted that ACE inhibitors derived from natural sources such as milk, eggs and vegetables tend to have fewer side effects. So the team engineered a breed of rice plant to produce a range of these compounds, along with a few chemicals known to relax blood vessels.

The researchers extracted protein from the transgenic rice and administered it to rats with hypertension. Two hours after treatment, the rats showed an improvement in their blood pressure. After a month of being fed flour made from the rice, the rats showed a consistent improvement, with the effect lasting for a week after the treatment was stopped.

The study reported no obvious side effects, and the researchers say that if the treatment protocol were to be scaled up to an adult human, they would need just half a teaspoon a day to treat hypertension.

There's a still a way to go before the rice hits the supermarket, however. Human trials would need to take place first and, of course, there's the growing debate about whether genetically modified crops should be allowed in the first place. Using genetically modified organisms (GMOs) to produce medicine is not unusual, however; an engineered variant of baker's yeast is used to produce a vaccine for hepatitis B, and a version of *E.coli* is used to make insulin for diabetics.

Other researchers are already looking into genetically modified plants that could produce the compounds needed to make treatments for HIV and diabetes.

FIRST SOFT-SHELLED DINOSAUR EGG FOSSILS IDENTIFIED

Some dinosaur eggs had soft and leathery shells like modern-day turtle eggs, a study led by the American Museum of Natural History and Yale University has found. The discovery was made after researchers analysed the mineral content of fossil eggs belonging to two dinosaurs: *Protoceratops*, a sheep-sized plant-eating dinosaur that lived between about 75 and 71 million years ago; and *Mussourus*, a long-necked, plant-eating dinosaur that lived between 227 and 208.5 million years ago.

"From our study, we can now say that the earliest archosaurs (the group that includes dinosaurs, crocodiles and pterosaurs) had soft eggs," said the study's author Matteo Fabbri. "Up to this point, people just got stuck using the extant archosaurs – crocodiles and birds – to understand dinosaurs."

PSYCHOLOGY

Largest ever study of exploding head syndrome sheds light on the sufferers of this mysterious condition

Exploding head syndrome (EHS), also called episodic cranial sensory shock, is a sensory disorder characterised by the perception of a loud noise or sense of explosion in the head, usually when transitioning into or out of deep sleep. Little is known about the cause of EHS and, while it's not dangerous, it can lead to fear, anxiety and interrupted sleep.

> "7 per cent thought exploding head syndrome was a side effect of medication"

Back in 2017, *BBC Science Focus*, in collaboration with psychologists at Goldsmiths, University of London, St Mary's College of Maryland, the University of Notre Dame, and the University of Sussex, launched a survey asking readers of the magazine to share their experiences of EHS. Nearly 7,000 of you replied with 3,286 reporting having experienced EHS episodes.

"I was delighted when the editor of *BBC Science Focus* Daniel Bennett, suggested this collaboration," said Dr Alice Gregory of Goldsmiths, University of London. "Dr Brian Sharpless led the first paper on EHS, but the dataset we collected was extremely rich and there's more to learn."

While 5 per cent of sufferers said they experienced EHS several times a week, most said they only experienced it occasionally – 35 per cent reported having an episode several times a year and 40 per cent having several episodes in their lifetime. Nearly 45 per cent of sufferers said they found the episodes frightening, with just over 25 per cent reporting significant levels of distress.

While the cause of EHS remains unclear, 60 per cent of sufferers believed it's due to 'something in the brain'. Nearly 35 per cent of sufferers thought EHS was due to stress, while 7 per cent thought it was a side effect of medication. Meanwhile, 2 per cent thought that it was caused by electronic equipment and 3 per cent thought it could be caused by something supernatural.

The measures taken by sufferers to combat EHS were varied. Among them were increasing alcohol consumption (deemed to be more than 80 per cent effective), avoiding sleeping on the back (also deemed to be 80 per cent effective), going to bed earlier (50 per cent) and getting more sleep (50 per cent).

"EHS isn't discussed very much. Consequently, people having this experience may have very little information about what's going on," said Gregory. "In our study, we found that those who had experienced EHS reported poorer sleep quality and less sleep than others. In future, we'd like to understand more about these associations. For example, could disturbed sleep trigger this experience or is it that someone who has experienced EHS finds it more difficult to fall asleep at night?"

ALAMY, GETTY IMAGES, M ELLISON/AMNH, SHUTTERSTOCK

GREEN PAPERS

The environmental stories you need to know

Words: **Jocelyn Timperley**

NGOs say that greener transport should be invested in, as we emerge from the pandemic

GREENER LAUNDRY HABITS CAN HELP FIGHT MICROFIBRE POLLUTION

The huge volumes of microfibres washing into Europe's rivers and seas could be reduced by up to a third with small changes to laundry habits, a study at Northumbria University has found.

An estimated 13,000 tonnes of microfibres are released from washing machines each year in Europe – equivalent to two rubbish trucks per day.

The researchers achieved a 30 per cent reduction in how much microfibre was released when they washed clothes in a 30-minute, 15°C cycle compared to a standard 85-minute, 40°C cycle.

SUSTAINABILITY

NGOs call for a post-COVID green recovery

Investment into renewable energy, green transport and ecosystem regeneration could boost the economy while benefitting the planet

Boris Johnson must implement policies to ensure a "resilient and inclusive" economic recovery in line with achieving net-zero emissions, a group of non-governmental organisations (NGOs) said in a letter to the prime minister in June.

The letter, signed by 57 leading charities including WWF, Oxfam, RSPB and the National Trust, urged the government to ensure public spending in the wake of the coronavirus pandemic puts the country on track to reach its goal of net-zero emissions.

All bailouts for business should also be conditional on plans and action to meet this goal, the letter added. It also called for support for the clean energy transition abroad, ending fossil fuel finance and helping developing countries to leapfrog to sustainable renewables.

SEAGRASS ENVIRONMENTS MUST BE SAVED

Seagrass meadows could be a powerful ally in the fight against climate change, according to a UN report. Though they cover only 0.1 per cent of the ocean floor, seagrasses store up to 18 per cent of the world's oceanic carbon, provide food and livelihoods to hundreds of millions of people and support a rich biodiversity. But these habitats are being lost at an alarming rate of 7 per cent a year, making their protection and restoration crucial. "Seagrasses represent powerful nature-based solutions to the climate challenge and sustainable development," said Susan Gardner, director of the ecosystems division at the United Nations Environment Programme (UNEP).

"We've got almost all the solutions we need to deliver net zero in the UK, and to deliver the emissions reductions we need globally," said Gareth Redmond King, head of climate change at WWF. "Why would we not invest in those? The green recovery is sustainable in lots of other ways, as well as environmentally."

The prime minister has previously agreed the recovery should be sustainable, but has so far provided few details on plans to do this. Green groups have criticised the huge amounts of stimulus money announced by many governments to support high-carbon industries, without any conditions to reduce emissions.

"We recognise the importance of maintaining our global leadership in the fight against climate change as we recover from COVID-19," a spokesperson from the Department for Business, Energy and Industrial Strategy (BEIS) told *BBC Science Focus*. "Our proven track record of cutting emissions while growing the economy will ensure the recovery is green, resilient and keeps us on the path to net zero emissions by 2050."

A host of other voices including business leaders, academics and politicians have also called for a green recovery in the wake of the coronavirus crisis. In May, the government's climate advisers urged them to focus on climate investments and avoid locking-in greenhouse gas emissions.

Cameron Hepburn, professor of environmental economics at the University of Oxford who was not involved with the letter, said there is a growing global consensus that a green economic recovery from COVID-19 could be better for jobs, the economy and the environment.

"Many of the specific policies outlined by the [NGO] report – particularly in renewable energy, electric vehicles and protecting and restoring key ecosystems – match those identified by leading economists as creating lots of jobs with strong short-term economic impact and long-term benefits for the climate," he said.

> **"The green recovery is sustainable in lots of other ways, as well as environmentally"**

INSPIRED
EXPIRED

COAL-FREE

Great Britain hit a milestone in June after its electricity grid went coal-free for two months – the longest period since the Industrial Revolution.

CUBAN CONSERVATION

Cuba's shift to conservation agriculture – a system based on minimal soil disturbance and diverse crop rotation – has led to rivers with low nutrient pollution and soil erosion, providing a model for more sustainable farming worldwide, said a study from the University of Vermont.

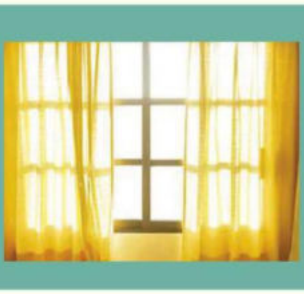
SWANNING OFF

Bewick's swans' wintering area has moved hundreds of kilometres east towards Germany over the past 50 years due to climate change, leading to a decline in the numbers found in the UK.

NOT SO GREEN AND PLEASANT LAND

Climate change could lead to shifts in the amount of vegetation grown in Great Britain, affecting how much carbon is stored, according to the University of Exeter.

IT'S EASY BEING GREEN



STAY COOL IN THE SUMMER

Setting up your home to stay cool in the heat will help you adapt to warmer weather without the need for energy-hungry air conditioning. Closing curtains and blinds during the hottest parts of the day can go a long way to keeping heat outside. Open windows at night to let cooler air in.

Trees and plants can act as natural coolers by releasing moisture into the air.

Turning off appliances and incandescent light bulbs can also prevent excess warmth from being released into your house. Fridges can also send out a lot of heat: ensure there is plenty of ventilation space behind them.

GETTY IMAGES X6

Gary Martin space expert

Horizons

What will the future of private space travel look like?

In the past, national space agencies have built and launched the craft that carried people into space. Recently, we saw a private company, SpaceX, launch American astronauts to the International Space Station (ISS) for the first time, ushering in a new era of private space travel

HOW BIG A CHANGE IS THIS IN THE WAY WE WILL EXPLORE SPACE?

We're starting a whole new chapter in humanity's quest to move off this planet, to actually start things we've seen in science fiction. The SpaceX launch, although it was still bought by government funds, is a huge change. It's something I've been waiting for all my career. Before, only governments had the kind of money, could take the liability, and actually had permission to go into space and explore this frontier. Now we've got a commercial company that has shown it can take an astronaut up to space into low Earth orbit.

WHAT KIND OF POSSIBILITIES DOES THIS OPEN UP?

There are a couple of private space station companies out there [Axiom Space and Bigelow Aerospace, who are both working on modules for the ISS] but until now you had no way to get there, because you would have had to get a government to sell you a seat. But the governments have other priorities and seats are precious. Now, SpaceX could sell you a trip to your private space station. And if all these countries are going to the Moon, there are a number of companies that are interested in providing communications around the Moon, providing resources and fuel and water and power. There are all kinds of economic possibilities in the next couple of decades that are now empowered. This is very exciting; this is a milestone that we will look back on and say, "This is when it started; this is when it really took off."

HOW DO YOU SEE PRIVATE SPACE TRAVEL OPENING UP THE EXPLORATION OF THE SOLAR SYSTEM?

At the beginning of the internet, you would never ever think of what a role it plays in our entire world right now. This is what I believe space is going to be like. So how do you start that? Well, this is where governments absolutely do work. It was NASA putting so much money into SpaceX that allowed it to have the capability to take humans into space. Now, SpaceX can amortise that investment to give anyone a ride, if they pay the price. And that's the difference, the government would never have that capability, they're not going to become an operational activity. But SpaceX is a private company that has motivations to do private things in space.

In Luxembourg, we looked at the places you could make money in space. Well, it's very expensive to take things from the Earth and use them in space. So, if you assume that governments are going to the Moon, everything you want for civilisation

SpaceX's Starship could take up to 100 people to the Moon

SPACEX

> "At Moon bases, you're going to be doing science, but you'll also want to have a beer at night, or have a pizza"

you're going to have to make in space at some point. At Moon bases, you're going to want to be out there doing science, exploring or having tourism, but you're also going to want to have a beer at night, you're going to want to have a pizza, you're going to want a comfortable, safe room. All of these materials and things and ideas have to be constructed by people in businesses. So the business opportunities at some point, maybe two decades or so from now, are actually limitless. Once there's a foothold of people on the Moon, then people will be going to Mars. We'll learn how to live safely, we'll learn how to do things in space. There's a lot to learn, and there are a lot of business opportunities in learning those things.

HOW MANY COMPANIES AROUND THE WORLD DO YOU ESTIMATE ARE BUILDING LAUNCHERS, EITHER FOR HUMANS OR SMALLER ROBOTIC CRAFT?

Every day I read a number of clippings to try to stay current and I'll tell you, there's a new launcher system proposed every week.

There are launcher systems all over the world in many, many countries, mostly those are to put things in low Earth orbit. The countries that can launch people are China, Russia and the US. India is working towards that capability. In the commercial role, only SpaceX has launched people into orbit, in addition there are only a few other US companies working to develop that capability: Blue Origin, Sierra Nevada, and Boeing. It's only a handful, but you wouldn't expect there to be a lot [of companies] until there's a lot going on and then people will rush to the marketplace. Think about it, if you're a country, let's say you're a Middle Eastern country with a lot of money, in a few years you could automatically go into the space age by just buying a private space station and buying tickets to get there from SpaceX. Now you're a country that went from no human spaceflight to your own space station. Because you can buy it.

SPACEX HAS SOME PRETTY WILD PLANS, INCLUDING A STARSHIP DESIGN WHICH THE COMPANY IS REPORTED TO BE PRIORITISING IN ORDER TO CARRY UP TO 100 PEOPLE TO THE MOON OR MARS. HOW SERIOUSLY SHOULD WE BE TAKING THESE PROPOSALS?

If you look at *Star Wars* movies and you look at *Star Trek*, whatever these inventive writers envision for the future, it gives the real engineers something to aim for – and some of it comes true. So, in a way, Elon Musk [SpaceX's CEO] is setting a vision, and engineers, like myself, all want to do exciting things. And so whether 100 people are going to be going to Mars anytime soon, that may or may not happen. But there are a lot of engineers and a lot of people who want to dedicate their lives to doing something exciting, that is different and that has never been done before. And so he energises amazing people who have already shown the amazing things they're able to do in space and he's got their creativity working.

GARY MARTIN

Gary Martin is the vice president far North American operations at the International Space University. He was formerly a senior advisor to the Luxembourg Space Agency, and director of partnerships at NASA's Ames Research Center.

Interviewed by Dr Stuart Clark

Johannesburg,
South Africa

ZOOLOGY

South African vets scan huge gorilla

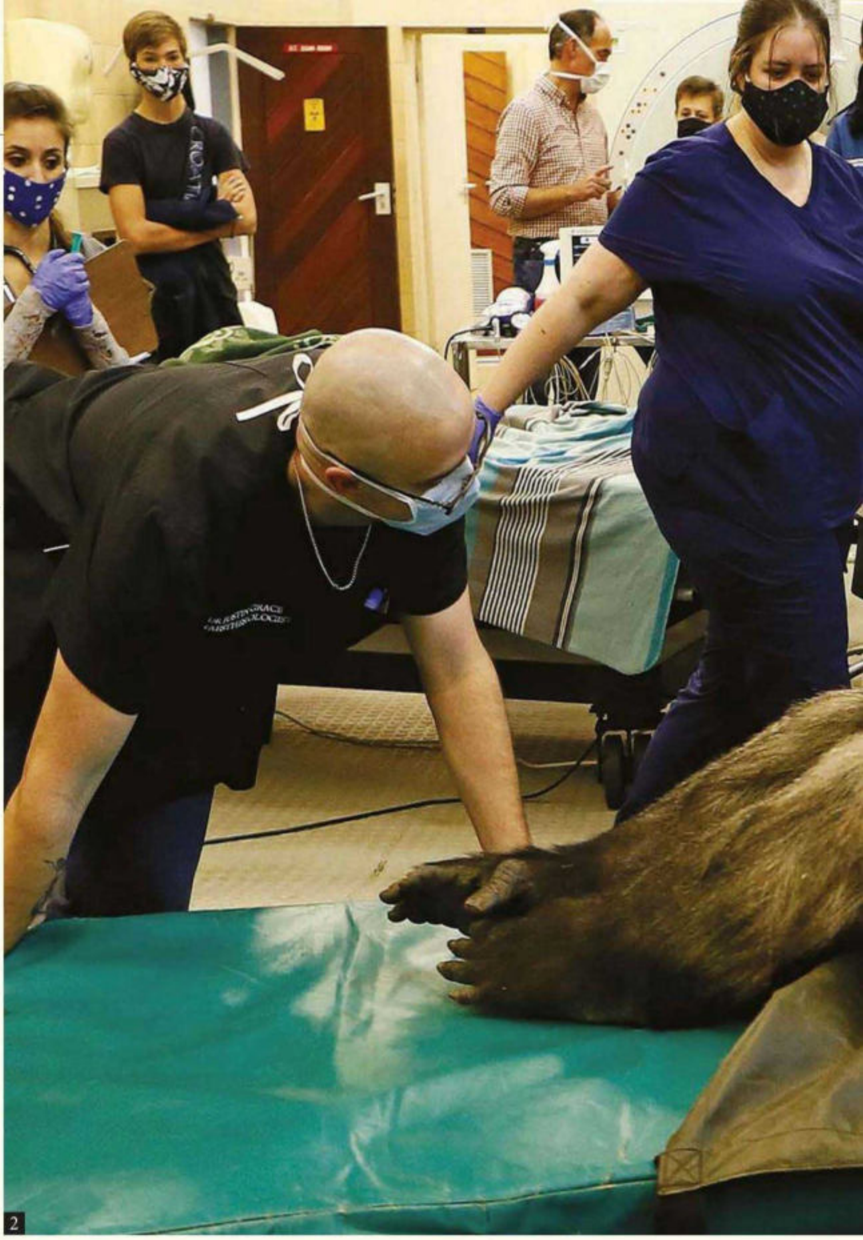
How do you look up a 210kg gorilla's nose? Carefully...

1. Makokou, a western lowland gorilla, lives at Johannesburg Zoo. In May, a biopsy revealed he was suffering from a series of polyps in his nasal passages. A CT scan was the only way to safely determine the extent of the polyps' growth, to help plan any future procedures. The zookeepers chose the Onderstepoort Veterinary Academic Hospital in Pretoria for the scan as it was the only facility nearby with equipment robust enough to handle Makokou's 210kg bulk. In early June, he was transported the 65km to the hospital via helicopter.

2. Thanks to Makokou's enormous size, it took five members of staff to manoeuvre him into position for the scan.

3. Once they had placed Makokou into the scanner, the team continuously monitored his vital signs – much like doctors would for a human patient – to ensure that he was safe at all times.

4. Following the successful procedure, the team at Johannesburg Zoo tweeted this picture of 34-year-old Makokou safely back in his enclosure. Two weeks later, he underwent state-of-the art surgery to remove the polyps, and is now making a speedy recovery.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GETTY IMAGES X4, THE JOHANNESBURG ZOO

NB !!!!!!
This door is to stay
Locked at all times.
Do NOT UNLOCK.
Thank You.
ZAH

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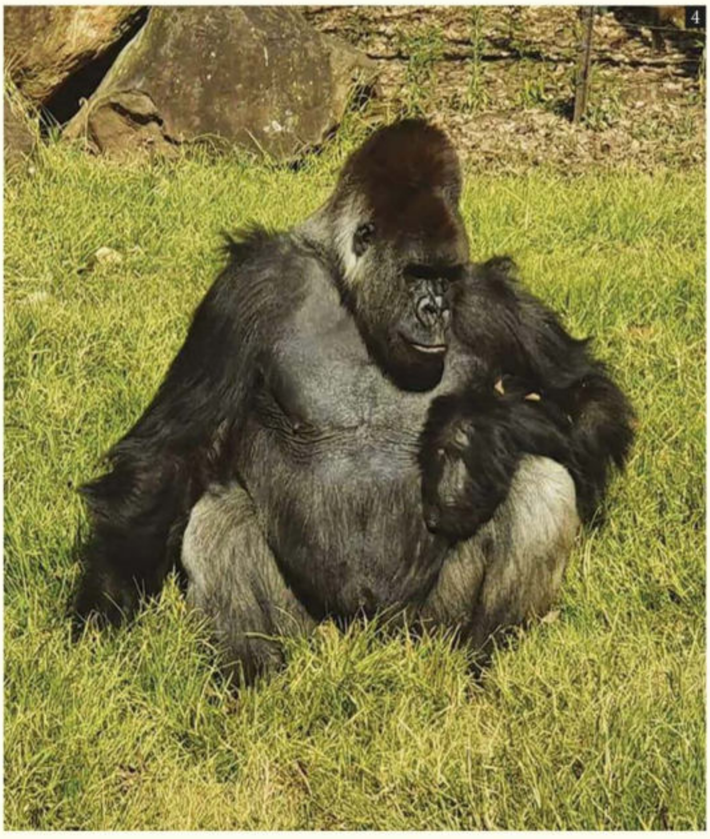
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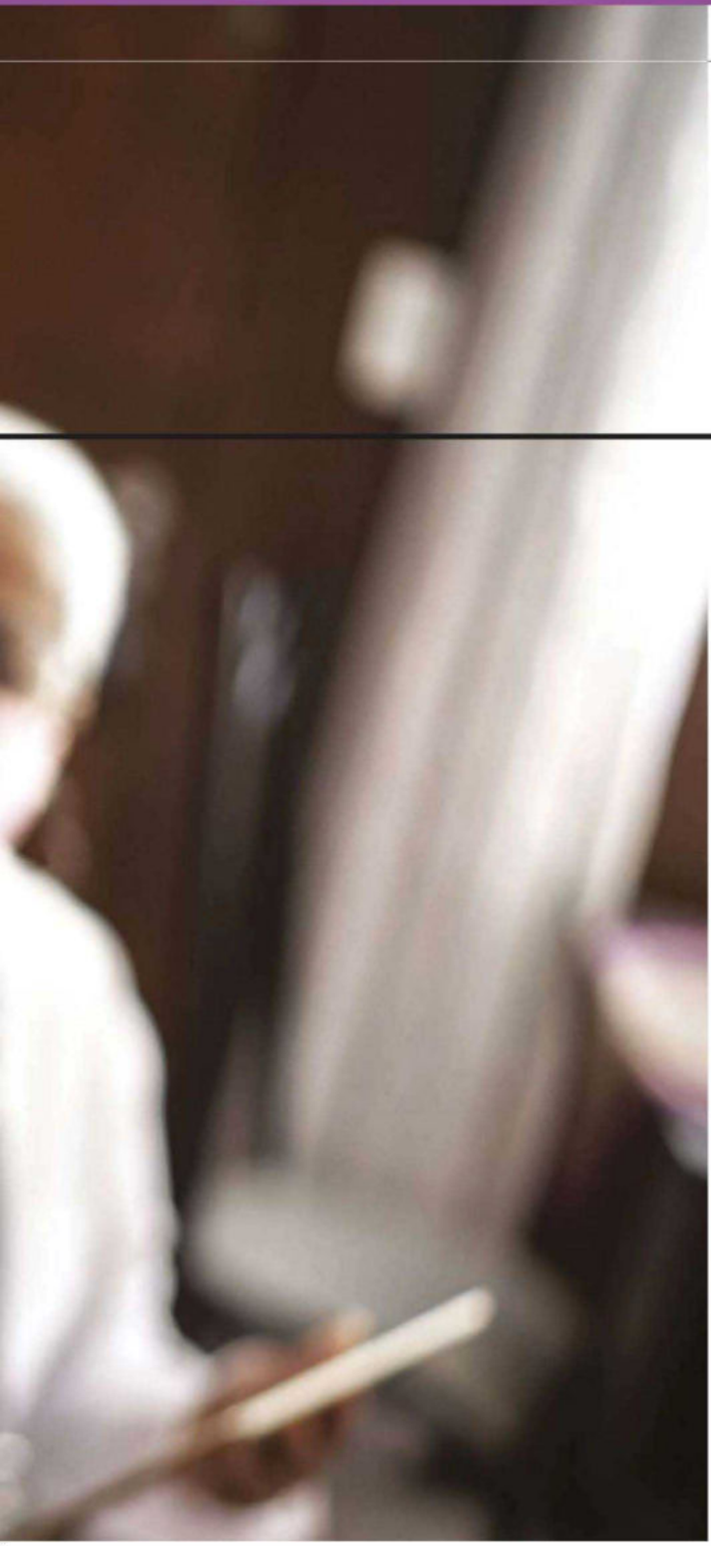
REVIEW

COVID-19: WHY ARE SO MANY BAME PATIENTS DYING FROM THE DISEASE?

Black, Asian and minority ethnic groups are dying from COVID-19 at disproportionate rates. What's the story behind the statistics?



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LEFT COVID-19 poses a greater risk to BAME people due to factors including economics and employment

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The COVID-19 pandemic has had a global impact, but its effects have hit some groups harder than others.

In the United Kingdom, more than 40,000 people have so far died from COVID-19, with people from black, Asian and minority ethnic (BAME) communities disproportionately affected.

A report published on 19 June by the Office for National Statistics (ONS) found that black men are more than three times as likely to die from COVID-19 than white men, while black women are almost 2.5 times as likely to die than white women.

People of Bangladeshi, Pakistani and Indian ethnicity are also significantly more likely to die from COVID-19 than white people.

A Public Health England report published on 2 June found that people from BAME backgrounds are also more likely to become infected with the coronavirus in the first place. For example, black ethnic groups are around two to three times more likely to be diagnosed with COVID-19 than white groups.

Similar patterns have been recorded within BAME communities in the US, particularly among African Americans.

"The pandemic has really exposed the vulnerability of certain communities because of the way in which people live and the way in which societies engage," says Dr Clyde Yancy, professor of cardiology and medical social sciences at Northwestern University, in the US.

There's likely to be a complex web of factors at play. One important statistic is that BAME groups are more likely to live in urban and deprived areas. The effects of COVID-19 are more pronounced in these areas, possibly because people are living in closer proximity and/or have reduced access to healthcare. BAME groups are also more likely to live in multi-generational and multi-family households, which also favour the virus's spread.

But even after adjusting for geographical region, population density, and socio-demographic and household factors, the ONS report still found that black men are twice as likely to die from COVID-19 than white men. And the raised risk for black women, and Bangladeshi, Pakistani and Indian men, also remains (see graph, overleaf).

WHAT ELSE IS CONTRIBUTING TO THE DISPARITY?

Underlying health issues could be another factor. COVID-19 is deadlier for those with existing medical conditions such as diabetes, obesity or cardiovascular disease. These conditions are more prevalent in certain ethnic groups: black and South Asian people, for ➲

ABOVE Many BAME people are employed in key worker roles, which have the highest exposure to COVID-19

GETTY IMAGES, ONS

example, have higher rates of diabetes than the general population, while older Pakistani men have especially high rates of cardiovascular disease.

Another key variable is occupation. Key workers – such as carers, nurses, doctors, security guards and bus drivers – face some of the highest levels of exposure to the disease, which puts individuals and their households at risk, and certain BAME groups are more likely to work in these roles.

An Institute for Fiscal Studies report led by Lucinda Platt, professor of social policy and sociology at the London School of Economics, looked into this in more depth. She and her co-author Ross Warwick found that working-age black Africans are 50 per cent more likely to be key workers than working-age white British people. Black African men are also 310 per cent more likely than white men to work in health or social care. And the Indian community make up 3 per cent of working adults, but around 15 per cent of doctors.

Platt and Warwick say that this "clustering of some minority groups in key worker occupations" is likely to be one of the contributing factors to the disproportionate BAME deaths.

Another open question is whether certain BAME groups could have a genetic susceptibility to COVID-19. But Yancy cautions against looking for a biological explanation – he believes that the differences in death rates are "less a function of biology and more a function of sociology."

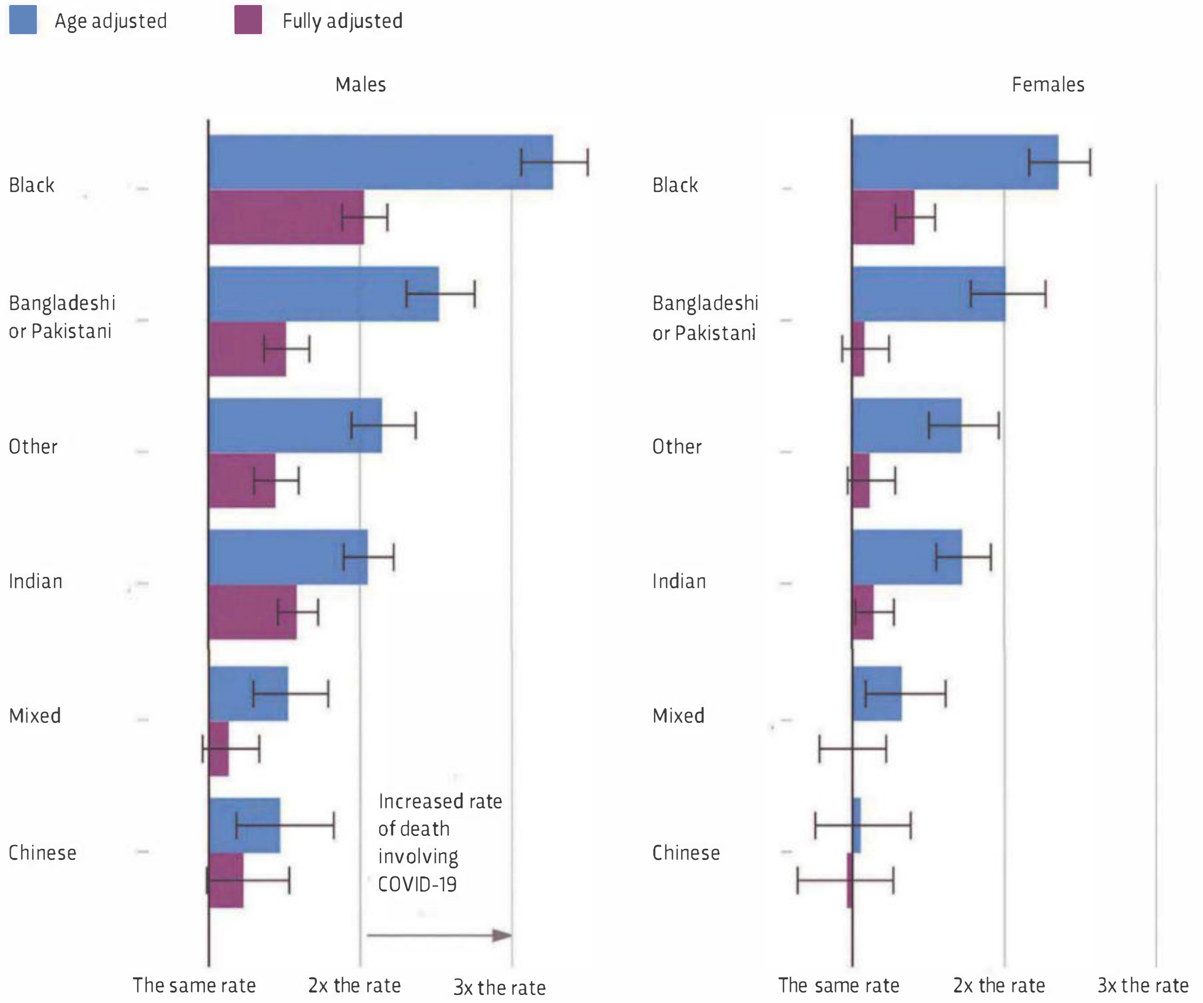
He notes that there are few health conditions with a strong biological connection to ethnicity. Usually, he says, there are underlying economic or social issues that can explain any differences in disease prevalence or death rates.

WHAT CAN WE DO TO ADDRESS THE IMBALANCE?

When the first Public Health England report was released, it was criticised for not providing any recommendations to protect ethnic communities. But a follow-up report released two weeks later shared seven recommendations, including improving data collection on patients' ethnicities, carrying out risk assessments for BAME key workers, and developing culturally sensitive health messaging.

The report said that "historic racism and poorer experiences of healthcare or at work may mean that

“Historic racism and poorer experiences of healthcare or at work may mean that BAME individuals are less likely to seek care when needed”



Rate of death involving COVID-19 for different ethnic groups compared to white people in England and Wales between 2 March and 15 May 2020

ABOVE This graph compares deaths involving COVID-19. The blue bars are age-adjusted, to allow comparisons between different age groups (COVID-19 affects older people more). The purple bars have been further adjusted to account for region, population density, social and household factors

BAME individuals are less likely to seek care when needed”. It also flagged up a lack of trust as an issue, with some BAME individuals worried about being deported if they went to hospital for treatment.

Platt, Yancy and other researchers are keen to see policies that address these issues. More collaboration with BAME communities could help to develop clearer messaging around COVID-19 and healthcare in general, which would be one way to build trust and reach those for whom English may not be a first language. Improved data collection, including the introduction of ethnicity on death certificates, would help to monitor BAME health over time and make it easier to spot any patterns that need looking into. “It’s not one big fix,” says Platt. “It’s looking at all the different elements of the system.”

by JUANITA BAWAGAN

Juanita is a freelance science writer who also works at the Abdul Latif Jameel Institute for Disease and Emergency Analytics (J-IDEA) at Imperial College London.

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INTERVIEW

SCIENCE HISTORY: DOES RENAMING A BUILDING REWRITE ITS PAST?

What message does naming a building after a scientist associated with eugenics send? And does rechristening that building simply hide the complicated truth?

Back in June, University College London (UCL) announced that it would be denaming the Galton Lecture Theatre as "one step in a range of actions aimed at acknowledging and addressing the university's historical links with the eugenics movement." Sir Francis Galton, whom the lecture theatre was named after, was a Victorian scientist who founded the British study of eugenics. But does removing Galton's name minimise, or even hide, his role in shaping our society today? We posed this question to Subhadra Das, a science historian and curator at UCL, who has spent the last eight years looking after the items in the university's Galton collection.

HOW DO YOU FEEL ABOUT THE RENAMING OF THE GALTON LECTURE THEATRE?

I'm very pleased, because it's something that people have wanted to happen for a long time and it's definitely the right thing to do. But I hope that my community at the university also realises that this is really just the beginning. That we've so much work to do when it comes to these ideas and these ways of thinking.

WHO WAS GALTON?

Sir Francis Galton is probably the most famous Victorian scientist not a lot of people have heard of. I had never heard of him until I started curating the collection. Galton was many things; he was an explorer in Africa, he was a meteorologist, a statistician, a biologist.

He's also the man who came up with the word 'eugenics'. He coined the term. I think a lot of people, if they hear the word eugenics, probably think about the Nazis and the horrors of the Holocaust. But actually, the story is a lot older and it's a lot more British than that.

EUGENICS HAS A BIG HISTORY IN THE UK THEN?

Absolutely. It's not something to be proud of, but it is a British invention.

Galton was probably as famous in his lifetime as his very famous cousin – a man called Charles Darwin. Galton added on to Darwin's theory of evolution his own particular genius. What he said was, if it's the case that humans are like any other animal, then we should be able to breed better humans in the same way that we breed animals to suit our own purposes.

Because of the time in which he was operating, his theories built on existing ideas to do with scientific racism. These were ideas that came out of the Enlightenment in Europe, ways of classifying different kinds of humans, ways that we now know to be incorrect.

Probably the most dangerous thing about those ideas was that there was a hierarchy involved. So having classified different human beings as being white or being European, or

COLLEGE LONDON

being black and being African, or being brown and from India like me, there was an inherent hierarchy that was put in place by European scientists – a hierarchy that they mistakenly believed meant white European people were better than everybody else.

BUT THAT BELIEF IN EUGENICS AND A HIERARCHY BETWEEN HUMANS IMPACTED THE ENTIRE SCIENTIFIC COMMUNITY, DIDN'T IT?

It did, entirely. Galton is essentially one of the founding fathers of modern statistics. He came up with the principles of correlation, regression to the mean, and was one of the founders of the biometrics school of thought. A lot of the work he did is fundamental to contemporary science and how it works. His ideas about eugenics weren't necessarily all that popular until the turn of the 20th Century. Eugenics probably took off in a considerably bigger way after his lifetime than during it.

The thing that I'm mainly concerned about is that we need to be very mindful of where his ideas were coming from and the ways in which they shape our ideas today. That doesn't mean to say that we throw all of Victorian science out the window and start again – of course it doesn't. These things are extraordinarily useful ways of approaching the world.

THE IDEA OF EUGENICS DIDN'T DIE WITH HIM, THEN?

The idea definitely didn't die with him. I think most historians of Galton would say that he would have been horrified by things that his ideas were put to. That he would have been horrified by the sterilisation of people without their consent in the United States. He would be horrified by the sterilisation and the extermination of people in the Holocaust.

My view on that is a little bit different, in so far as he may well have considered these to be the important and Earth-shattering historical developments that we think them to be, but I don't know that he would necessarily have thought they were a bad thing. But I need to explore that a little bit more, how he would feel about these things.

There's an interview that he gave to a newspaper called *The Jewish Chronicle* [in 1910]. A Jewish journalist asks him how he feels about the persecution of Jewish people in Russia, and Galton's response was that it's difficult to talk to any individual political moment, but that in general, this person – this Jewish person that he was speaking to – should be grateful that those weaker and lesser individuals within that person's race, as he saw it, were being exterminated for them, because it meant that the Jewish race would become stronger as a result.

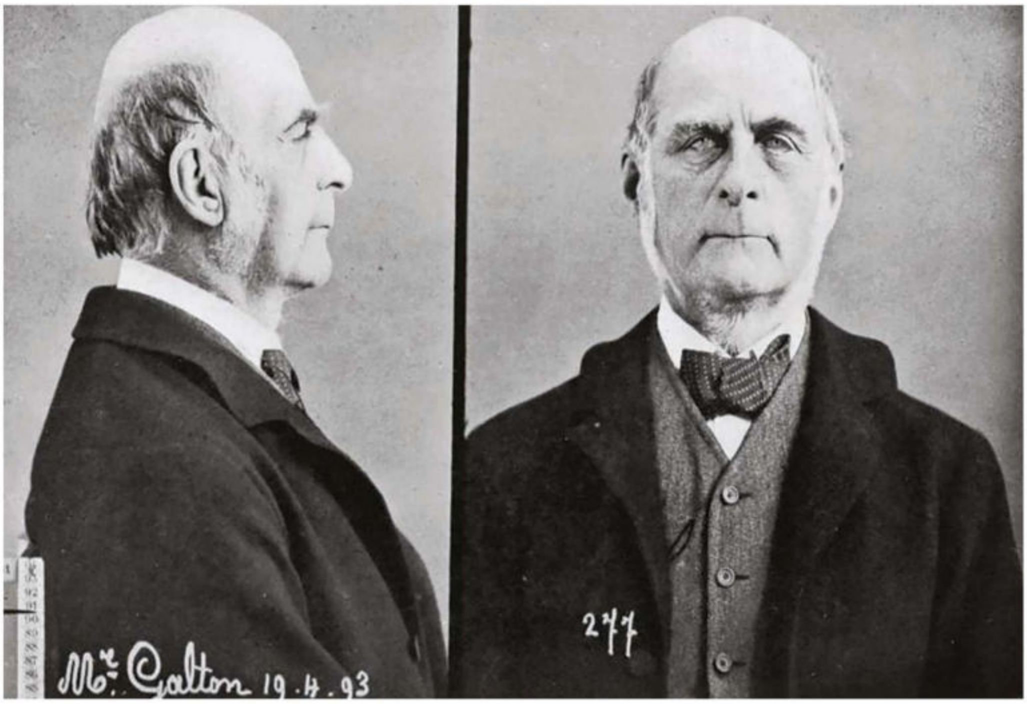
That journalist asked him, "Don't you feel that that's a very immoral position to hold?" And what Galton said was that it is neither immoral or moral. It is amoral. It has nothing to do with morality. And that's where things start to become really dangerous, because if scientists believe their work to be apolitical, or that it has nothing to do with morality, that is where disaster strikes.

WHY IS IT A PROBLEM THAT UCL HAS A LECTURE THEATRE NAMED AFTER SIR FRANCIS GALTON?

As a historian, I used to be in two minds about this. UCL has also got a whole building named after Karl Pearson, who was as ardent a eugenicist, if not more so, than Galton himself. [Since this interview took place, the Pearson Building has been renamed.] We've also got a museum named after William Matthew Flinders Petrie, an Egyptologist and archaeologist who contributed a lot to the science of eugenics at the turn of the 20th Century.

ABOVE University College London's Galton Lecture Theatre, Pearson Lecture Theatre and Pearson Building are now known as Lecture Theatre 115, Lecture Theatre G22 and the North-West Wing respectively

ALAMY



ABOVE Francis Galton, aged 71, photographed on a visit to Bertillon's Criminal Identification Laboratory in 1893

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While those buildings had those names, I had thought that it meant that those names were at the forefront of people's minds and it meant that it kept the story alive. But, in the interim and in the last few years, I have realised that keeping the names of people who were involved in developing a science which meant that people who look like me were deemed to not be fit to live… I don't see how that can be anything other than phenomenally painful and inappropriate.

The naming of buildings is a clear act of commemoration. I think that in that aspect, it's something that we shouldn't be doing. In a way, it's kind of the same thing as putting up a statue, because what that's doing is saying 'these are people that we respect' and 'we value their ideas' and 'we are the kind of society that wants to hold these people up'.

First of all, I don't feel like that is the society that we are. But also, I just don't feel like it's a good thing to do.

AS STATUES ARE PULLED DOWN AND NAMES OF THINGS ARE CHANGED, SOME PEOPLE SAY WE ARE 'ERASING HISTORY'. WHAT WOULD YOU SAY IN RESPONSE TO THAT?

I'd say that isn't how history works. And, I'd say that it was exactly the opposite.

This is just based on my personal experience of teaching the history and philosophy of science at the university, from which I say that Sir Francis Galton is the most famous and influential Victorian scientist most people have never heard of.

To me, the fact that his story has allowed to be forgotten and also the story of scientific racism, more widely, has been allowed to be forgotten, really is part of the problem.

It seems like it's contrary to everything I work towards in terms of decolonising and diversifying the curriculum, but this really is one old, dead, white man that needs to be written back into the history books.

In museums and with a lot of history programmes, we talk about hidden histories and that isn't actually inaccurate. But the point is that if these histories have been hidden, it means that someone hid them. So, by bringing them out into the clear light of day we're not erasing history. Telling these stories is actually widening the frame and telling a fuller picture.

WHAT OTHER CHANGES WILL WE SEE TO MUSEUMS?

We've seen museums acknowledging their own racism and their own role in perpetuating these ideologies.

A really good example is the Tenement Museum on the Lower East Side of New York City. They've always been a politically actively minded museum, and they've made it clear that they have listened and taken on the message of the problems to do with race in US society.

UK museums are starting to do the same thing as well. Somerset House made an anti-racism pledge, noting that black people are under-represented across their organisation.

The more that we all start to realise that this is to do with all of us and scientists, people who work in museums, people who are science communicators, people who are public historians, the responsibility is on all of us to start telling these stories more accurately and to acknowledge the privilege and the position that we're in. **SF**

with **SUBHADRA DAS** *(@littlegaudy)*

Subhadra is a science historian and curator at University College London. ***Interviewed by*** **BBC Science Focus** ***editorial assistant Amy Barrett.***

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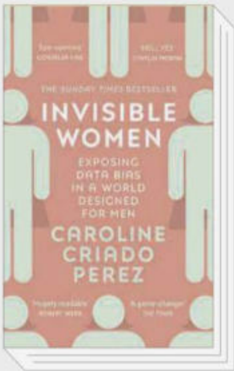
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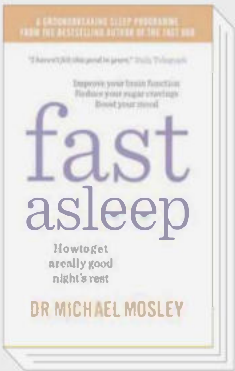
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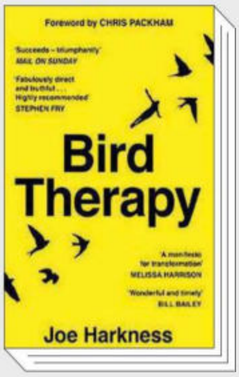
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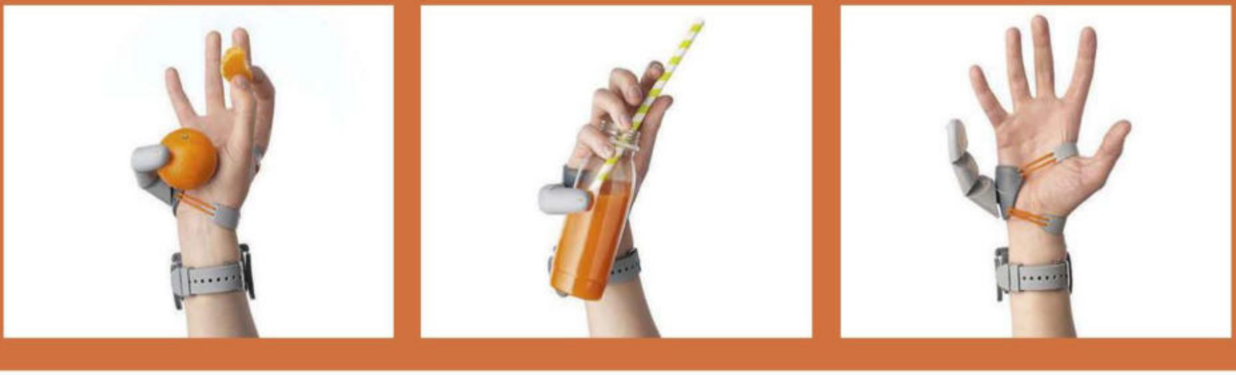
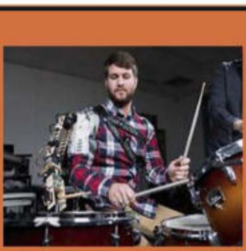


The 'thumb' of The Third Thumb project has two degrees of freedom, allowing it to grip and hold objects

THREE MORE ROBO-UPGRADES

Extra arm



In 2016, researchers at Georgia Tech unveiled a robotic arm that drummers strap to their shoulders. The arm responds to the music's tempo and rhythm.

Robot suit

A suit controlled by brainwaves has allowed a paralysed French man to move all four of his limbs. It works via electrodes implanted on his brain's surface.

Key implant

VivoKey's implantable chips allow people to open doors, share data or access websites with a wave of the hand. They work a bit like contactless credit cards.

PROSTHETICS

Human augmentation rewires the brain

Scientists discover what happens to our neural circuitry when we learn to use robotic upgrades

What would you do with an extra thumb? Master that tricky guitar chord? Become a volleyball pro, perhaps, or an expert shadow puppeteer?

Scientists and engineers have long been interested in augmenting the human body with extra limbs or fingers. We've previously seen drummers with three arms, and robotic sixth fingers for stroke patients. Now, a project called The Third Thumb has shown how the brain adapts to an extra body part.

The Third Thumb is the work of Dani Clode, a designer and researcher at University College London's Plasticity Lab. Her device is a 3D-printed prosthetic that is controlled by the feet. Pressure sensors underneath the big toes detect movement and relay that information via Bluetooth to a watch strap, which is equipped with two motors that control the thumb via Bowden cables – similar to those used in bike brakes. The flexible thumb has two degrees of freedom (each controlled by a big toe), and it moves uncannily like the real thing.

> "IT WILL BE OF GREAT INTEREST TO THOSE DEVELOPING BRAIN-CONTROLLED PROSTHETICS"

DANI CLODE/DANICLODE.COM/INSTAGRAM @DANI_CLODE

In a recent study published on the preprint server bioRxiv (an online archive of studies that are yet to be peer-reviewed or published in a journal), Clode and her colleagues investigated what happens in the brain when people gain an extra digit. Over five days, they trained volunteers to use the thumb, asking them to complete tasks such as building *Jenga* towers, picking up wine glasses, and scooping marbles out of cups. Before and after the training, the volunteers had their brains scanned using fMRI (functional magnetic resonance imaging).

The researchers' focus was on a particular region of the brain called the 'primary sensorimotor cortex', which is activated when we move our fingers. They wanted to find out whether training with the thumb could affect this region. And their preliminary results suggest that it can – after training, a volunteer typically showed fewer differences between the brain activity patterns for individual fingers. In other words, the finger activity patterns were less defined, which suggests that training with the thumb weakened the hand's representation in the brain.

This is an example of the brain's plasticity – its ability to rewire itself when faced with new experiences or situations. More research is needed to understand why these brain changes take place, and what their effect might be.

The findings will be of great interest to those developing the next generation of brain-controlled prosthetic devices. This technology "critically relies on our brain's ability to learn, adapt and interface with these devices," write the researchers. "Importantly, though, such successful human-robot integration may have consequences on some aspects of body representation and motor control which need to be considered and explored further."

Six of the best... kitchen gadgets

Work smarter in the kitchen, with **Daniel Bennett's** pick of the tech that will help you express your inner culinary genius. Bon appétit...

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While the office has been shut, I've been relying on the pour-over method to brew my coffee. This technique means you simply pour hot water over coffee grounds on top of a filter. It's a barista-favourite, but it hasn't quite hit the mark of a freshly brewed coffee from a shop. The ENA 8 is as close as you can get to the coffee-shop experience, while staying in the confines of your home. It's a clean, compact design that serves up 10 different types of coffee, from espressos to flat whites to lattes via a sharp 2.8-inch touchscreen. Or you can even order a coffee from the machine while staying snug in bed, by using the Jura smartphone app. The coffee is smooth and rich, and offers all the extra flavour you get from grinding your own beans, only with none of the work.

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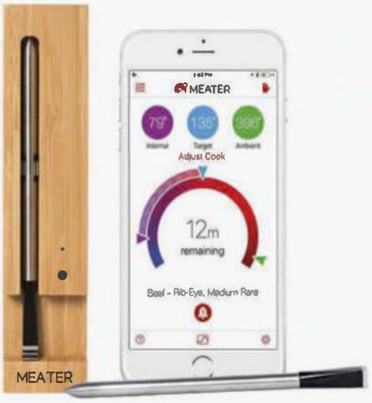
You can make a great pizza in a conventional oven with a bit of knowhow, but to achieve an authentically crisp base with a charred crust and perfectly cooked toppings you need a cooker that can crank up the heat. Of course, the ideal solution is to clear out the garden and build your own wood-fired oven from clay bricks and eat like Donatello, Leonardo and co. But if that seems a bit over the top, Ooni's range hits a sweet spot between convenience and authenticity. The Koda 16 comes ready-built – all you have to do is hook it up to a gas supply. The Koda jettisons flames in an L-shape along the sides of the oven, heating the interior to a maximum of 500°C. It takes all of five minutes to set up and 20 more to get to optimum temperature – just be sure to rotate the pizza once for an even finish.

£399, uk.ooni.com



↑

Meater

It doesn't look like much, but this is one of our all-time favourite pieces of smart home tech. The Meater is a meat thermometer that links up to your smartphone via Bluetooth to tell you the interior temperature of whatever you're cooking. Better yet, tell Meater what you want to cook and it'll measure the temperature inside your oven – which is never what the knob on the front says – and it will estimate how long it'll take to cook a perfectly pink leg of lamb, for example. Essentially, it takes all the guesswork out of your meaty feasts, and you don't need to open the oven door. I owe many a perfect Sunday roast to this little metallic sous-chef.

From £79, store-uk.meater.com

←

Livin Farms Hive Explorer

If you're feeling *really* adventurous in the kitchen, then you could try getting your protein from something crunchier than steak. Eating insects instead of meat takes a massive chunk out of your carbon footprint; with this in mind, the Hive Explorer is meant to open people up to the idea of insect agriculture. The mealworms eat your food waste – scraps of vegetables and grains are ideal – and poo out fertiliser that you can use on your veg patch or house plants. You allow some of the mealworms to pupate into adult beetles, which then reproduce and repopulate your farm. Other mealworms you harvest and eat – it's the circle of life, minus Disney. Its makers suggest grinding them up to make meatballs, or roasting them for a crispy, nutty addition to a salad. Yum. And if you can't face that, then garden birds will happily accept them.

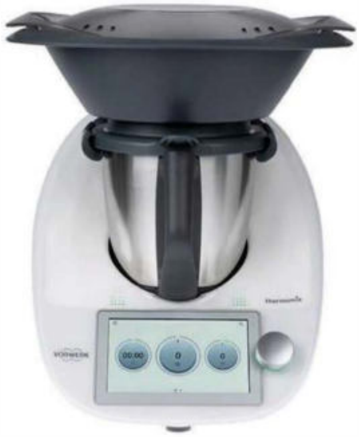
$149.99 (£121.50 approx), livinfarms.myshopify.com

→

Thermomix TM6

This is probably as close as you are going to get to having a robot chef in your kitchen. In effect, the Thermomix takes most of your kitchen equipment and crams it into one machine that can chop up your veg, pan fry and then blend into a soup in one pot. The central temperature controls on the pot mean you can use Thermomix to carry out some more delicate culinary techniques, like sous-vide, fermentation and slow-cooking. Or you can just use it to cook rice, knead dough or whip cream. There's a scale for weighing what you put in, so the machine knows exactly what's what, and it's all controlled via a smart touchscreen that will present you with recipes made for the device. Teach it to swear and Gordon Ramsay's out of a job.

£1,149, vorwerk.co.uk/thermomix



←

Instant Pot Smart Wi-Fi

The Instant Pot is everyone's new favourite kitchen gadget. Hugely popular with time-starved parents, it's essentially an electronic pressure cooker and slow cooker rolled into one. This means you could transform a pork shoulder into tender pulled pork inside half an hour, or knock out a chilli in even less time. Alternatively, you can set and forget the device for a few hours to slowly cook a stew or make perfect rice. This new version now adds Wi-Fi connectivity and an app, so you can operate the machine remotely and get notifications when your food is ready. If you're really short on time and energy this will be a bonus, as you can throw the ingredients in and fire up the cooker while you're out so that dinner's ready when you get in. The app also features recipes that have been specially designed for the Instant Pot, to keep things breezy.

$129.99 (£TBC), instantpot.com

harman/kardon

Ideas we like...

Glass speakers

Back in 2000, Apple partnered with Harman Kardon to create the iconic SoundStick speakers, designed by Jony Ive. This update to the original design is arguably even better. The wireless speaker boasts a 360° sound system that pumps out audio in all directions, so that the music sounds fantastic wherever you are in the house. The inner glass dome is lit with LEDs, to create an ambient light system too.

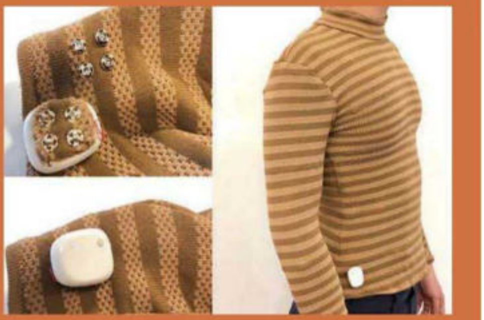
We haven't listened to it with our own ears, but this is definitely a speaker that would look good at home.

Harman Kardon Aura Studio 3
£279.99, harmankardon.co.uk

Geodesic tents

With lockdown rules easing, but some flight restrictions still in place, it's time to give camping a second chance. Inflatable tents are the way to go if you're driving to your campsite – and Heimplanet's is our favourite. This new four-person Backdoor tent is a reinvention of their classic design: you simply peg down the perimeter and pump up the beams and you're good to go. The smart vent system means it can be used in any season, even the unreliable British summer. Plus, there is tonnes of storage inside, along with an area in the back that's dedicated to stashing your bags.

Heimplanet Backdoor
€899 (£824 approx), heimplanet.com



Sensors sewn into fabric

Engineers at MIT have come up with a way to incorporate biosensors into stretchy fabric. The idea is to create clothes that can detect simple vital signs like temperature, respiration and heart rate. In the past, sensors have been embedded into skin-like patches that have to be taped down, but this design weaves long flexible strips of sensors into narrow channels in the garments. These channels house small openings that let the sensor arrays touch the skin. As well as helping athletes measure performance – imagine a football team kitted out with these shirts – the clothes could help doctors monitor patients when they're at home. Next, the researchers want to look at whether they can incorporate different sensors, such as blood oxygen level monitors.

Everything you need to know about the PlayStation 5

Last month, Sony unveiled its long-awaited next-generation console. Here's what we know so far...

When's it coming out?

'Holidays 2020' is all that Sony has committed to. This typically means early November, perhaps after the Thanksgiving holiday, though we're keeping our fingers crossed that the COVID-19 outbreak hasn't caused setbacks.

How powerful is it?

Without drowning you in jargon, analysts have estimated it's between two to three times more powerful than its predecessor, the PS4, but a little underpowered compared to the Xbox Series X (also due for release later this year). But the PS5 is boasting near-instantaneous memory, meaning it can load game worlds in a flash. If the last generation is anything to go by though, it won't be the hardware that decides which is the best console to buy. It'll be the games available.

Why does it look like a massive internet router?

We're not architects, but the Sony design team seems to have taken its cues from the likes of the Sydney Opera House and the Guggenheim in Bilbao, opting for something more sculpted than previous iterations. We'll reserve judgment until we see it in the flesh. Although to be fair, we don't spend a tonne of time gazing at our games consoles...

What games will be available?

The exclusive launch titles are promising. As well as a sequel to the hugely popular *Spiderman* game, there's a new iteration of the motorsport simulator *Gran Turismo* and a follow-up to the original *Horizon Zero Dawn* called *Horizon Forbidden West*, among others. Over the last few years, Sony has built up an incredible roster of exclusive series, and if it can hang on to them it'll certainly be our first console of choice.

What new features are there?

Backwards compatibility – the ability to play games from previous generation consoles – has been an area of focus this time around. Sony has said that it expects the majority of the PS4's library will be playable on PS5, but it hasn't quite explained how that will work in practice. Will you simply be able to put your old discs in? Or will it only work with online purchases? Watch this space.

We were particularly intrigued by Sony's new sound engine. Sound design is often overlooked, but games like *Hellblade: Senua's Sacrifice*, in which you follow whispers around the level, show how powerful it can be. And we're intrigued by the idea that you can configure your game installations, installing just the multiplayer component of *FIFA*, for example, so you can save on space. And of course, it'll be interesting to discover what's in store with virtual reality, once that's revealed in more detail.

"BACKWARDS COMPATIBILITY HAS BEEN AN AREA OF FOCUS"

And the price?

This is yet to be revealed. There are two consoles – a digital-only version without a disc drive, and a version that can handle physical media. The best guess is around the £400 mark, with the disc drive version costing more.

So, Xbox or PlayStation...

It's too early to tell. But it certainly looks like both systems are correcting the mistakes of their forebearers to build consoles that are more versatile than ever. It's going to be a good year for gamers.

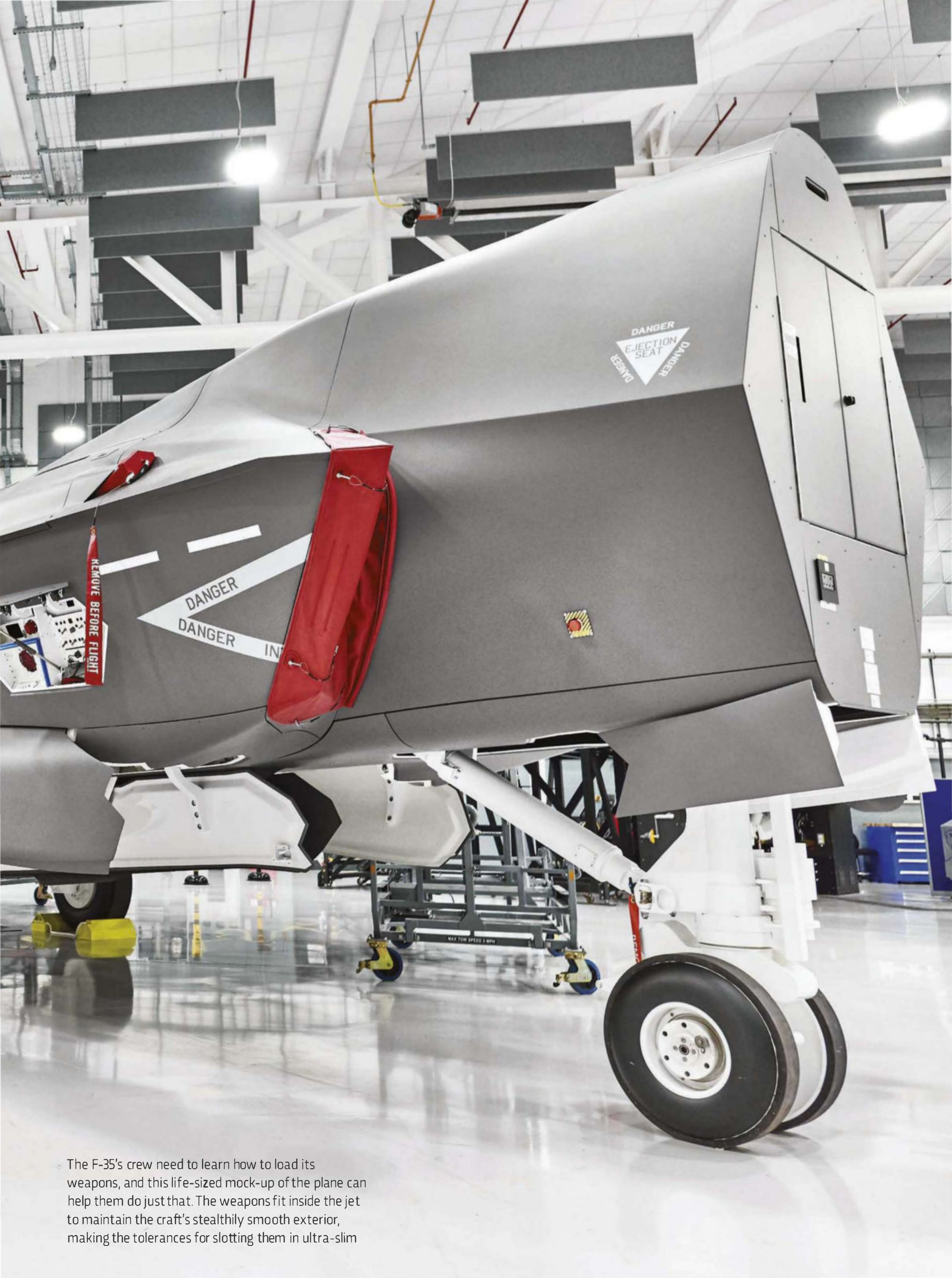
The new PlayStation hides plenty of power within its unusual shell

REMOVE BEFORE FLIGHT
REMOVE BEFORE FLIGHT

GREAT BALLS OF FIRE

WITH *TOP GUN: MAVERICK* DUE TO HIT CINEMAS LATER THIS YEAR, WE WENT BEHIND THE SCENES AT RAF MARHAM TO GET UP CLOSE TO THE NEW F-35, THE FIRST FIGHTER JET THAT DOES (MOST OF) THE FLYING FOR YOU

WORDS: STEPHEN DOBIE PHOTOGRAPHY: STEVE SAYERS


DANGER
EJECTION SEAT
DANGER
DANGER
REMOVE BEFORE FLIGHT
DANGER
DANGER
IN

The F-35's crew need to learn how to load its weapons, and this life-sized mock-up of the plane can help them do just that. The weapons fit inside the jet to maintain the craft's stealthily smooth exterior, making the tolerances for slotting them in ultra-slim

DANGER
EJECTION SEAT
DANGER
DANGER
WARNING
WITHIN

Well, a Tornado is your old push-button phone with the antenna coming out, whereas the F-35 is your iPhone."

Jim Beck is the station commander of RAF Marham in Norfolk, UK. Clearly identifying my scrambled brain, he's breaking down into the baldest terms just what a revolution the Royal Air Force's new F-35 Lightning II jets – which live at his base – represent.

"This jet fuses all the data it receives together and only presents about 1 per cent of it to the pilot, when a human decision is required. The actual flying of it is the easiest bit. You don't even think about it any more."

For those of us with wild fighter pilot daydreams fuelled by *Top Gun* clichés, these advances could be rather disheartening. Just as our smartphones are seldom used for actual voice calls, the F-35 will rarely find itself in a Bruckheimer-esque dogfight.

HIGH FLYER

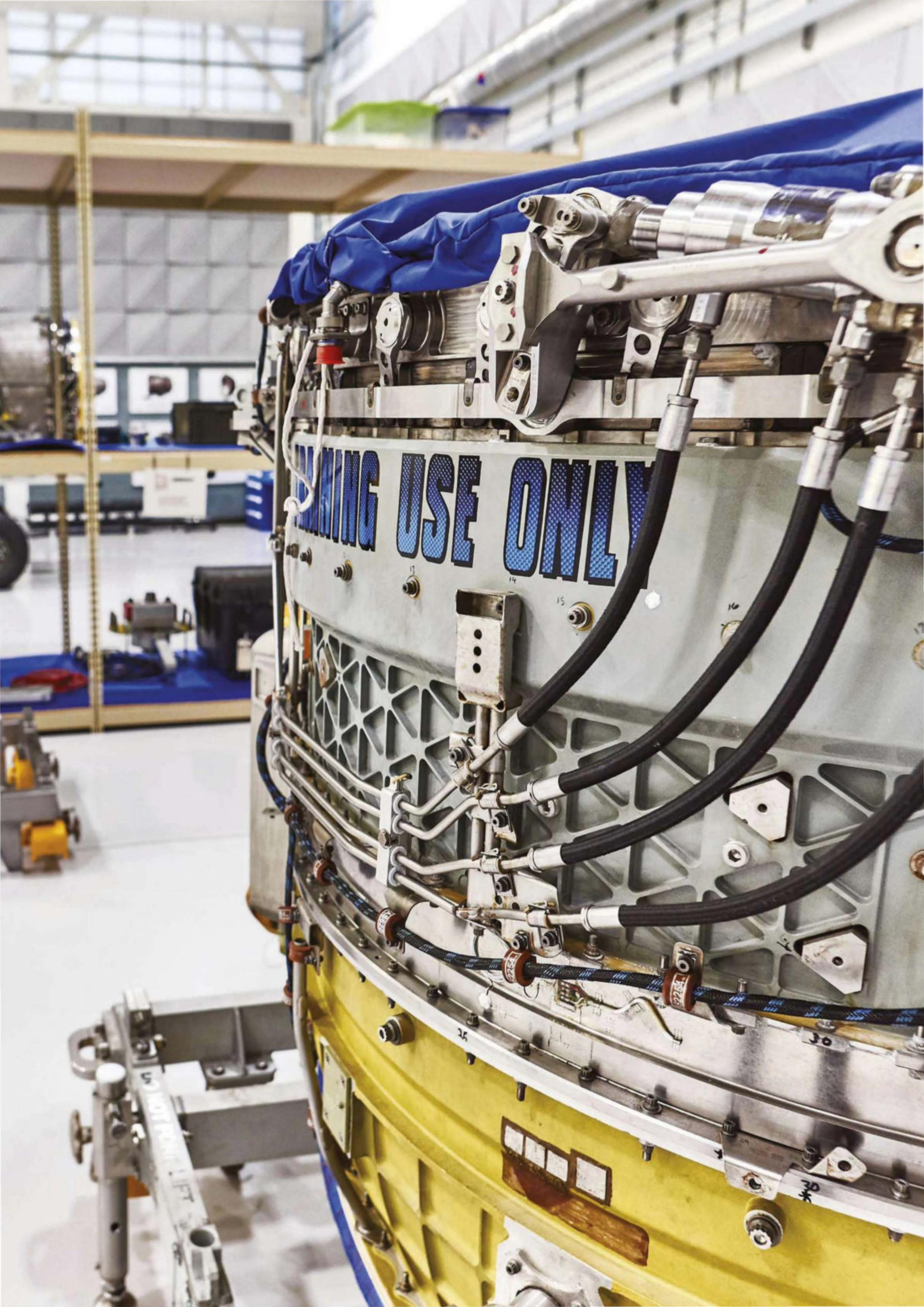
This fifth-generation fighter jet is designed to be so much more multi-faceted than all that's gone before it, and less likely to get itself into a confrontation in the first place. It's more about acquiring targets than attacking them, using its super-stealthy coating to sneak undetected into enemy territory before painting a vastly detailed picture of the battlefield for a team of people who'll fire its

ABOVE The cockpit is as classified as you'd expect, but is inevitably much more screen-led than jets from a generation before. Vital displays are fed into a bespoke-fit, highly intelligent helmet, allowing physical controls to be minimal. Placing even more prominence on...

RIGHT ...the ejector button. It'll fire the pilot from 0 to 60 metres in 1.5 seconds, and so smoothly that no amount of safe expulsions will medically bar them from flying again. Here, we're poking around the mock cockpit used to train the crew in maintaining the ejection system

RESCUE
REMOVE BEFORE FLIGHT
REMOVE BEFORE FLIGHT
Cvi

> "JUST AS OUR SMARTPHONES ARE SELDOM USED FOR ACTUAL VOICE CALLS, THE F-35 WILL RARELY FIND ITSELF IN A BRUCKHEIMER-ESQUE DOGFIGHT"


AINING USE ONLY

weapons remotely. Or a gaggle of nimble fourth-gen fighters behind it that'll swoop in and do the dirty work.

"The human still decides whether to fire a missile or drop a bomb," Beck assures us. "There is a morality around warfare and some ethical decisions. At the moment no machine will ever make those. That's why we're still in the cockpit.

"That is fundamental to the way the RAF and Royal Navy do business. But we've got there by getting smarter and smarter. I'm in a great position now where my uncertainty of what's going on is negligible. With certainty, I know 'that's the enemy, I know he's doing a bad thing and I've got to make the decision to drop the bomb'.

"People think the move into fifth-generation jets is about stealth. It isn't. It's about information. Whoever has the most – which is of decision quality – will win the fight," Beck says.

INFORMATION WINS

With information the F-35's biggest weapon, it's something that needs sternly protecting. So Marham's 150-strong cyber team is on the clock 24/7. All of the jet's systems can be taken offline at any second, allowing it to function even if the cloud it usually connects to has been compromised.

The Lightning II's intelligence stretches to predicting its own needs, so after each flight its maintenance crew will plug it into the network, where the jet will advise what – if anything – failed during the flight or needs some attention in the near future.

I'm taken on a tour of Marham and spend an hour in the classroom. This is where the maintenance crew learn their trade, on something unemotionally named the Air System Maintenance Training (ASMT) system. In short, it's a virtual fighter jet that you move an avatar around, with a bank of tools to drag in to help you learn every possible servicing or repair job before you're let loose on a real-life jet. It operates a lot like virtual reality, but without the discombobulating headset.

As well as reserving any rookie errors for a mock environment, the virtual system also saves the hours it can take to laboriously remove panels to get under a real F-35's skin. The fighter jet is so hard to get inside because the panels are often masked over so that no gaps or rivets break its sleekness. The craft needs to be as smooth as possible so that it can evade radar and maintain its exceptionally high stealth levels. Not only is the removal of panels tricky, the resealing process once you've popped them back on is drawn out, too.

Next door to the ASMT room is the laboratory where students learn how to fix this 'low observation' surface of the craft. While this lab also has computerised processes, with its focus on fine craftsmanship it feels like more of a blast from the past. There's even a paper sheet on the wall to help both trainers and trainees convert from the F-35's imperial measurements – betraying the aircraft's US manufacturer – into the metric they most likely know.

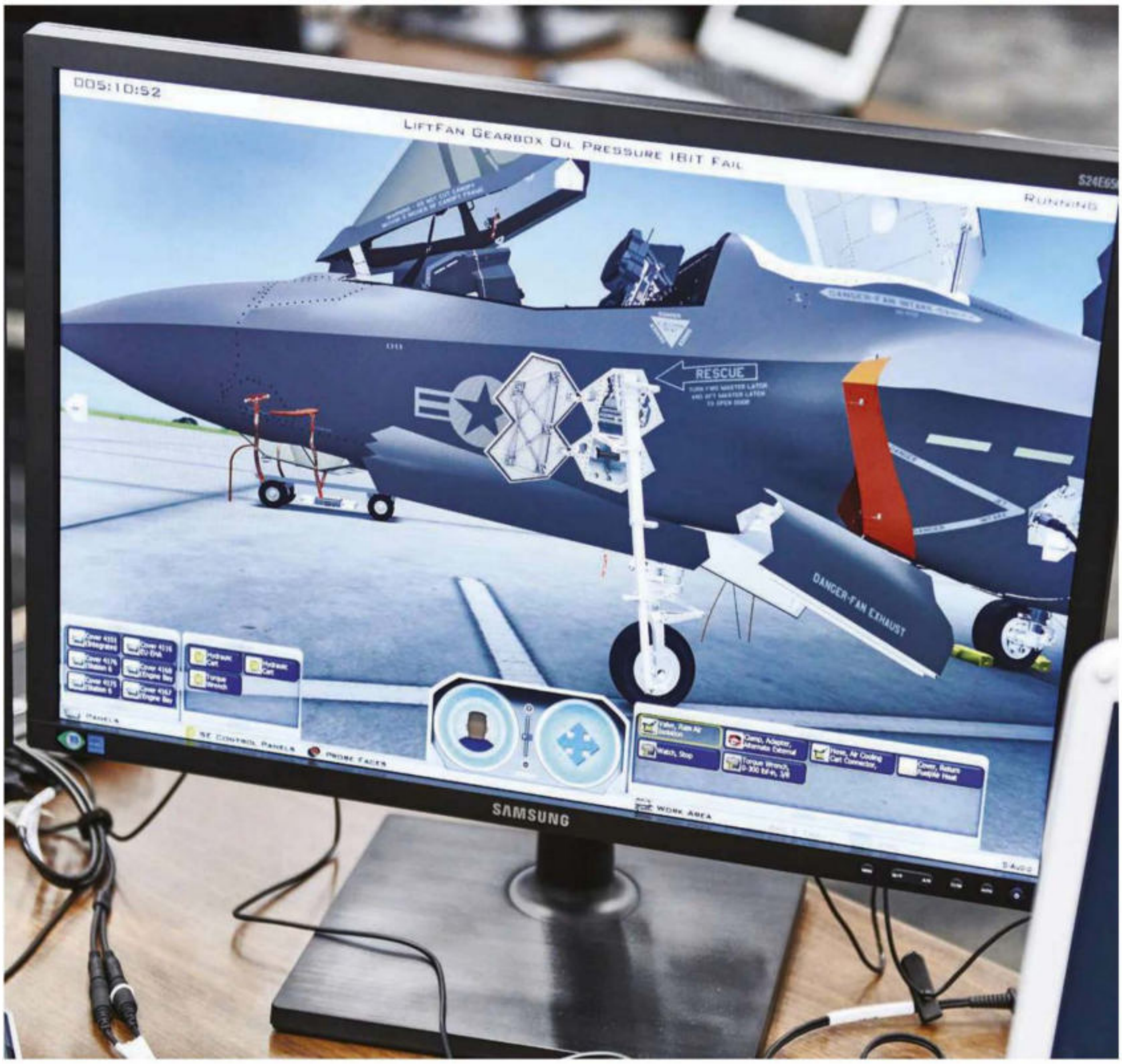
One big question looms large, though. Is the F-35 just too clinically adept to make its pilot a hero?

"Not when you're doing 'doggers', as we call them," Beck says. "We fly a thing called angle of attack [AOA]. While a Tornado could go 19AOA, we're going to 50AOA. We just keep going up, and the last person to stop going

"PEOPLE THINK THE MOVE INTO FIFTH-GENERATION JETS IS ABOUT STEALTH. IT ISN'T. IT'S ABOUT INFORMATION"

LEFT The F-35 used by the RAF utilises a 29,000 horsepower Rolls-Royce lift fan for its vertical take-off and landing tricks

ABOVE The lab where you learn how to maintain the jet's stealthy surface. It contains significantly fewer screens than other training rooms, as students hone a precision hand skill. Out on aircraft carriers, the jet's brain will detect blemishes in its invisible armour to tell its crew exactly what needs patching up



LEFT Learning how to virtually maintain an F-35 on the Air System Maintenance Training system has boundless benefits: no costly mistakes on a £100m jet, quick and easy access through panels, and the ability to peek into gaps that your head would never fit into on the real thing

BELOW Jim Beck is station commander at RAF Marham and has flown F-35s more than anyone else on site. He's racked up 900 missions since 2014: 300 in the air and 600 on the simulator

up will win that fight. And that's absolutely exhilarating. If I tried that in a Tornado I'd be in a parachute. There is a bit of romance about flying older planes, but we're a professional force and it's more about what the jet can do. The dogfight takes place on the information spectrum now.

"All the controls only move for human comfort, the jet doesn't need them to operate. They're about making it easier for pilots to comprehend. It's making me feel good by moving left. You ask the jet 'can I do something' and the jet will do it if it's safe to do so. It won't let you fly into the ground or into another jet, it'll just say 'no!' It's just breathtaking, it really is."

So there's little chance you'll end up in the disastrous flat spin that leads to Goose's galling demise in the original *Top Gun*, then.

"I like talking about the jet, it's my second favourite subject," concludes Beck, with a wry grin. "What's the first? I'm a pilot..."

Maybe there's a little bit of Maverick in him after all. **SF**

by **STEPHEN DOBIE**

Stephen is a journalist for BBC Top Gear *magazine.*

BBC
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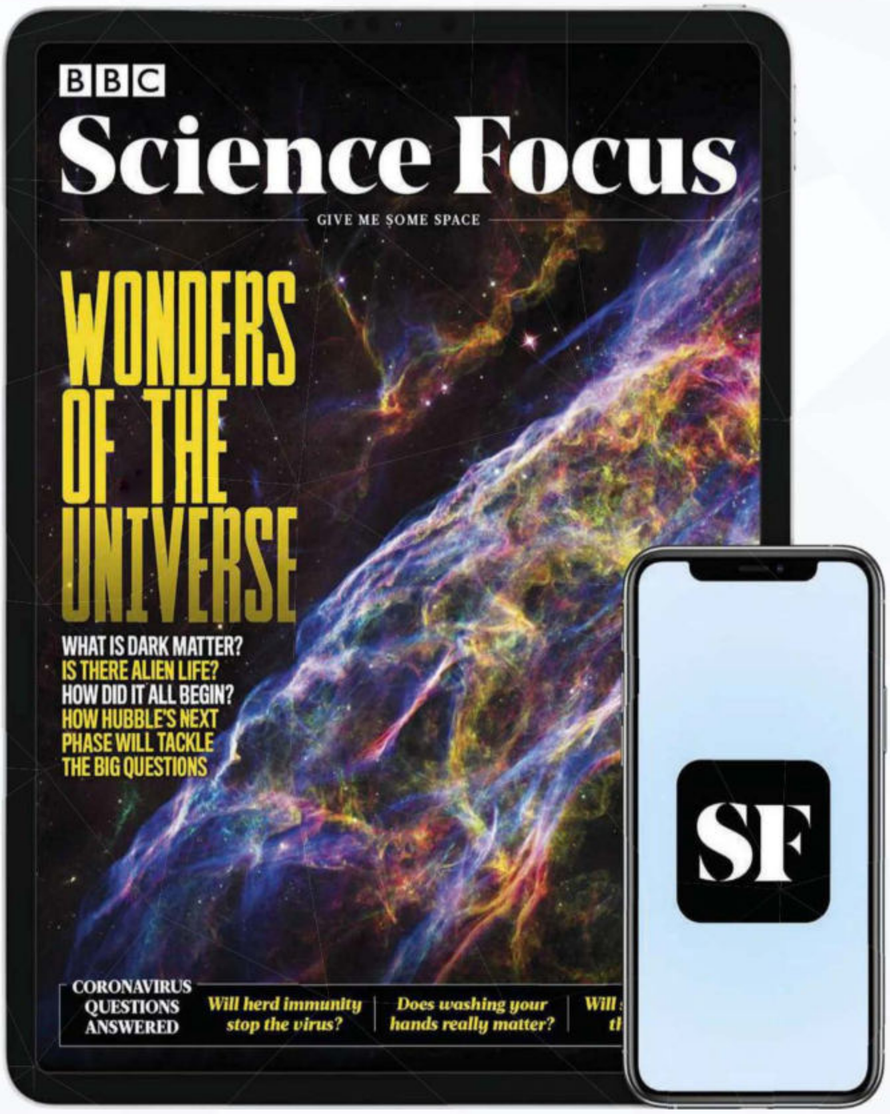
MAGAZINE


BBC
Science Focus
GIVE ME SOME SPACE
WONDERS OF THE UNIVERSE
WHAT IS DARK MATTER?
IS THERE ALIEN LIFE?
HOW DID IT ALL BEGIN?
HOW HUBBLE'S NEXT PHASE WILL TACKLE THE BIG QUESTIONS
CORONAVIRUS QUESTIONS ANSWERED
Will herd immunity stop the virus?
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THE NEXT

GIANT LEAPS

From spider robots to antennas on the Cornish coast, these UK-based projects are laying the groundwork for a permanent station on the Moon. Wallace and Gromit would be proud…

by **DR STUART CLARK**

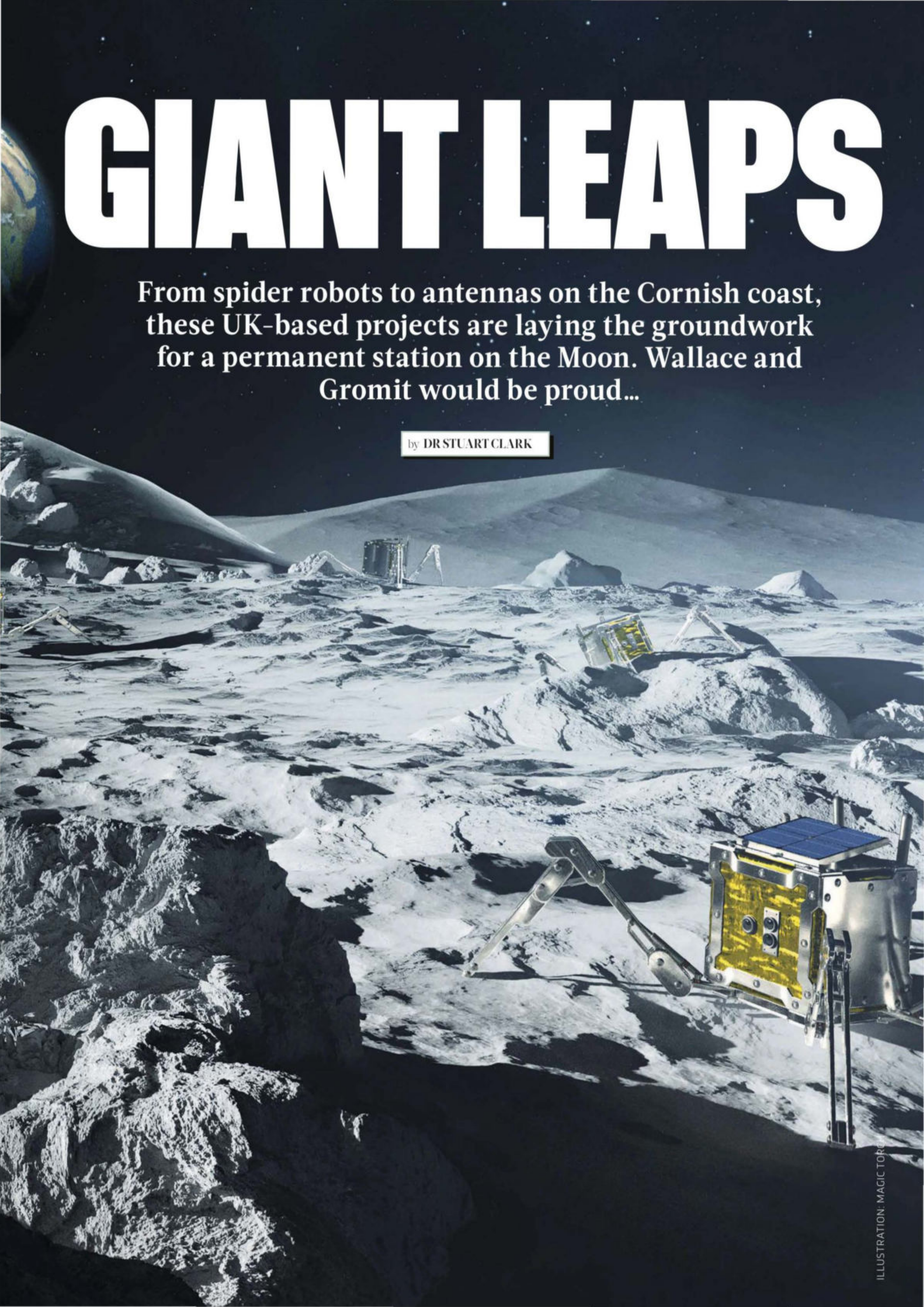
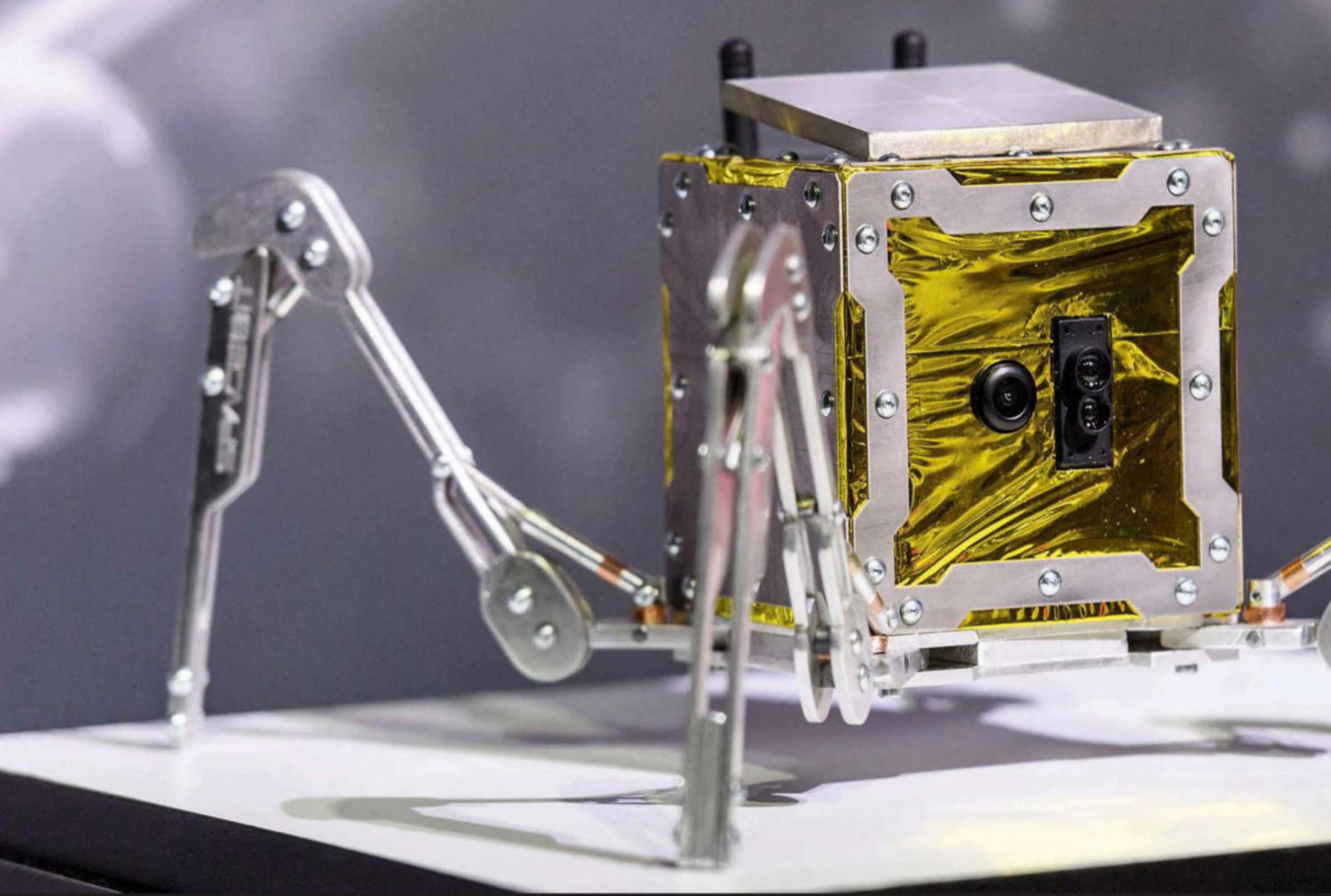


ILLUSTRATION: MAGIC TORCH



ABOVE The asagumo spider robot will walk across the lunar surface to investigate lava tubes

RIGHT In this graphic of asagumo, you can see the 'feet' on the end of the legs, which should stop the robot from sinking into the regolith

About this time next year, a small robotic spider may be taking its first tentative steps on the Moon. It's not exactly The Spiders From Mars, but the late David Bowie will have played a part in getting it there.

Pavlo Tanasyuk, CEO and founder of the British company Spacebit, remembers once listening to David Bowie's *The Rise And Fall Of Ziggy Stardust And The Spiders From Mars* and wondering about one day building rovers with legs rather than wheels. The idea lay dormant until Tanasyuk was visiting a friend at the Japan Aerospace Agency (JAXA), and mentioned his long-held idea of a spider robot on Mars or the Moon. The friend responded immediately with the Japanese proverb of the asagumo, the morning spider who brings fortune. "That's when it clicked and I decided that we actually should be doing this rover," says Tanasyuk.

He incorporated the UK company Spacebit to begin developing the asagumo spider robot. Launch is now scheduled for July 2021, onboard the Peregrine lander that has been developed by the private American company Astrobotic. Peregrine will be flown on a Vulcan Centaur rocket, and if all goes to plan, asagumo will be the UK's first lunar lander.

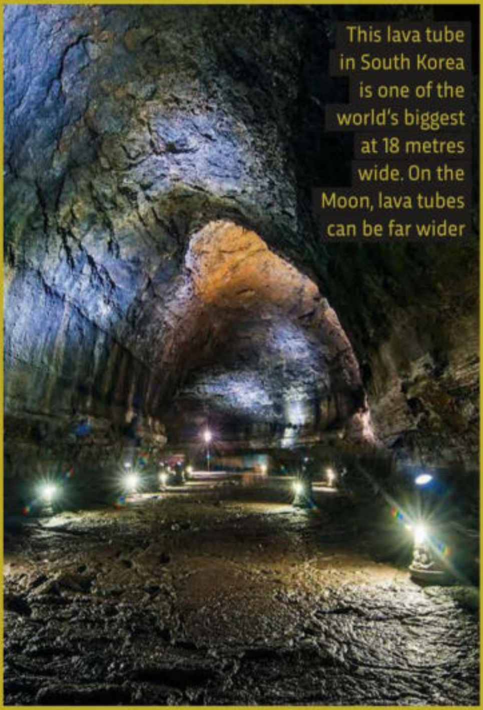
Walking on the Moon is tricky because of the regolith, which is the layer of rock fragments and dust that covers the lunar surface. For a walking rover the dangers are two-fold. First, the legs can sink into this layer, impeding the movement. Second, the dust and fragments can get into the articulated parts of the legs and the motors, causing them to cease up.

To overcome the first problem, Spacebit is designing the legs to look more like ski poles, which have pads on the end to stop them disappearing beneath the surface. As for the second, it is a risk that the team are willing to take because they don't want their rover to walk on the surface indefinitely, just long enough to get to their real target: a lunar lava tube.

LAVA PALAVER

A lava tube is a natural tunnel formed by rivers of lava flowing away from a volcano. The top of the flow is exposed to the cooling air, and gradually hardens to solid rock, forming a roof over the lava flow. When the lava has all drained away it leaves an empty lava tube. Since the Moon was once volcanically active, there are thought to be an abundance of lava tubes there.

Inside a lava tube, there is much less dust but more rocks, so legs are actually better suited to clambering over obstacles. "We already did tests in the lava tubes of Mount


This lava tube in South Korea is one of the world's biggest at 18 metres wide. On the Moon, lava tubes can be far wider

WHY SHOULD WE EXPLORE LAVA TUBES?

Lava tubes on the Moon are interesting to research, because not only do they provide information about the Moon's volcanic history, but they could also offer natural shelters for astronauts. Living on the Moon involves facing hazards that are aren't present on Earth, thanks to its protective atmosphere. For example, meteorites that would burn up in Earth's atmosphere will pummel the lunar surface, and harmful radiation that is blocked by our atmosphere and magnetic field will reach the Moon's surface too. Having a thick, rocky, ready-made roof over a lunar base is therefore a good idea. On Earth, lava tubes are often just a metre or two across. In the lower gravity of the Moon, they can be hundreds of metres wide and over a kilometre long. One example, in the Marius Hills region of the Moon, has been estimated to be at least one kilometre in width and height – enough to hold a whole town or small city.

SPACEBIT X2, ALAMY

Fuji in Japan. I went inside the lava tube with the rover, and we tested how it walks. Basically we can see that the legs are better suited for the lava tubes than wheels [as legs let the robot clamber over obstacles]," says Tanasyuk.

There are some lava tubes in the vicinity of the Peregrine lander's touchdown area, and one of these will be the first target for the asagumo. The reason for the interest in lava tubes is that human bases may one day be constructed inside these natural rock formations.

While Spacebit may be sending the UK's first Moon lander, it is far from the only UK space mission that is currently in development. Indeed, it is just the tip of the lunar iceberg…

FIRST STEPS

The UK's lunar expertise has been built up since the days of NASA's Apollo missions, which took astronauts to the Moon in the late 1960s and early 1970s.

Planetary scientists Grenville Turner and Colin Pillinger were two pioneers of UK space science. They were held in such high esteem that they were granted access to the lunar rocks that the American Apollo astronauts brought back to Earth. This was an accolade in itself. "You had to be the best of the field to actually get access to these samples," says Sue Horne, head of space exploration at the UK Space Agency. She adds that Pillinger and Turner were "wizards at instrumentation".

Together, the pair established the UK's excellence in the area of cosmochemistry, analysing samples not just from the Moon but from meteorites, some of which are now thought to have come from Mars. They also trained many students over the years who themselves have gone on to successful science careers, training more people in the process.

"We are world-leading in the area of cosmochemistry," says Horne. As a result, the UK now routinely supplies key instruments for various science missions carried out by the European Space Agency (ESA). These include the comet-chasing mission Rosetta, the recently launched Solar Orbiter, and the forthcoming JUpiter ICy moons Explorer (JUICE). By supplying instruments and expertise, the UK's scientists gain full access to the mission. "By working with Europe, we can do a lot more than we can afford individually," says Horne.

The collaboration is set to continue in the future. For example, the Open University is developing a miniature chemical analysis laboratory for ESA. Called ProSPA, the lab will fly on the joint Russian-ESA Lunar Resource Lander mission (Luna 27) in 2025. The company MDA UK is also working on the same mission, building a vital component of the autonomous landing system, a LiDAR to measure the distance to the ground.

And the UK's ambitions do not stop there.

GOING DEEPER

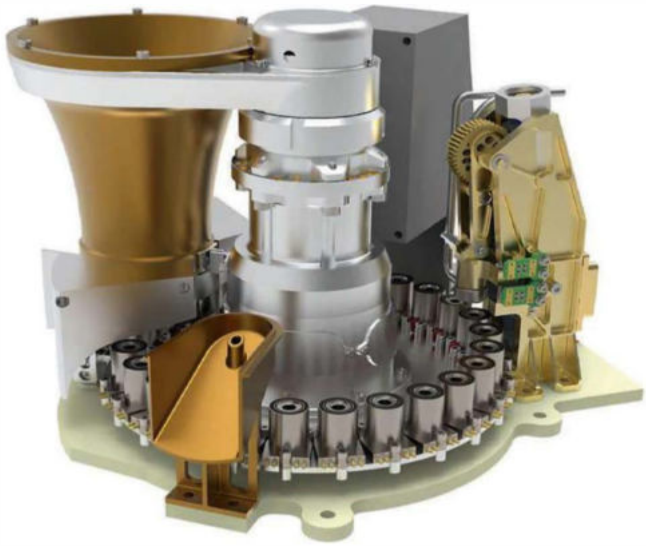
Beyond science, Horne and her colleagues have identified an emerging need in space exploration: deep space communications. This may not sound glamorous, but it is going to become increasingly important as more and more people send spacecraft to the Moon.

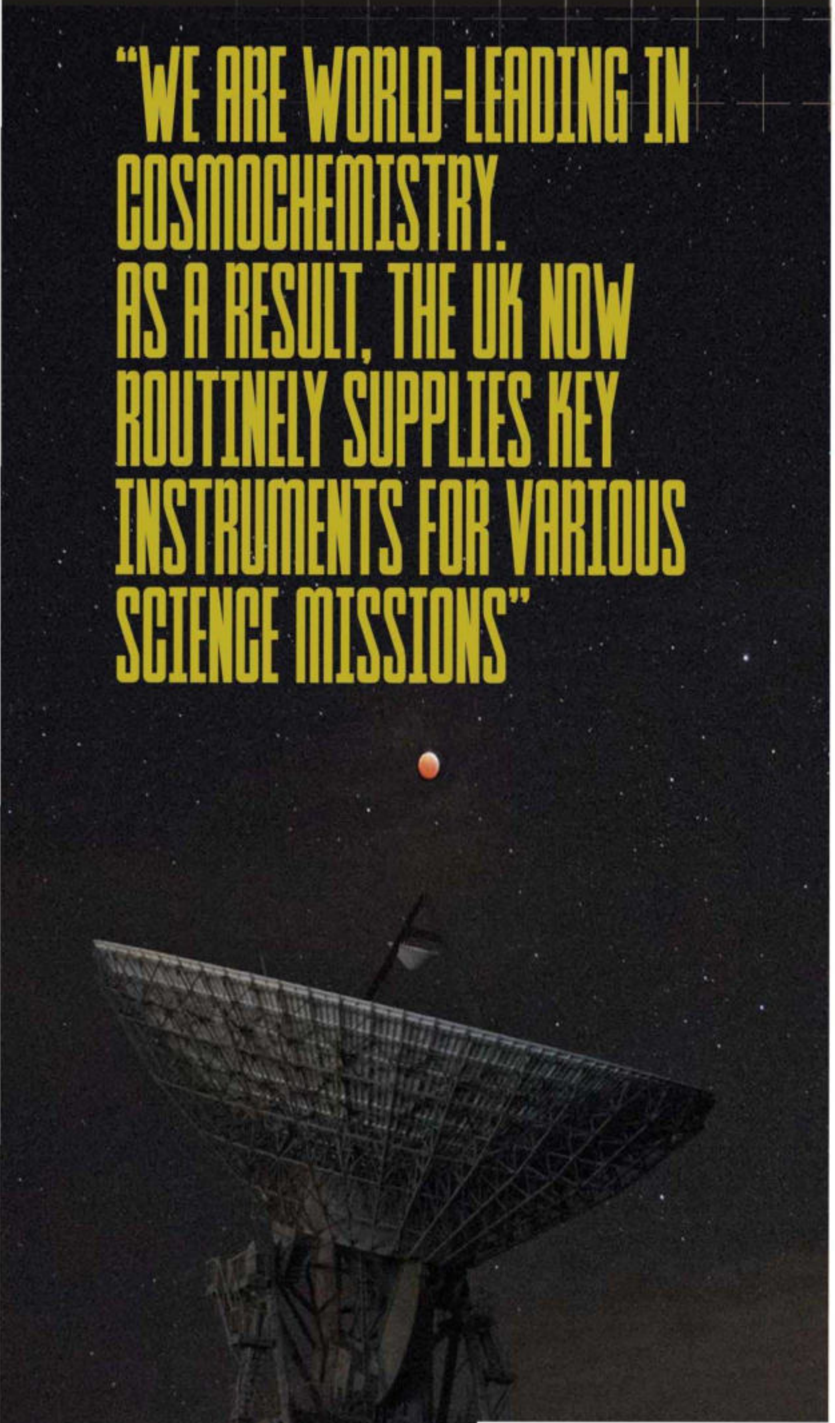
In the past, virtually every lunar mission has had to carry a transmitter powerful enough to

ABOVE LEFT Pavlo Tanasyuk, CEO and founder of British company Spacebit, and the man behind the spider bots

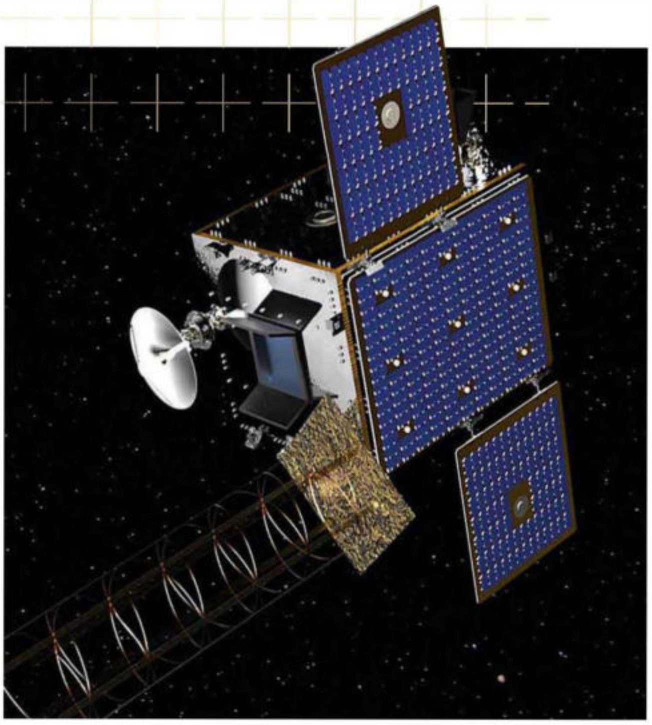
BELOW The ProSPA chemical analysis lab is being developed by the Open University and will travel to the Moon in 2025

SPACEBIT, ESA, GOONHILLY EARTH STATION LTD/NATHANIAL BRADFORD, SSTL





"WE ARE WORLD-LEADING IN COSMOCHEMISTRY. AS A RESULT, THE UK NOW ROUTINELY SUPPLIES KEY INSTRUMENTS FOR VARIOUS SCIENCE MISSIONS"



beam signals back to Earth. Now, however, the UK is building a dedicated communications satellite to orbit the Moon. Called the Lunar Pathfinder, it will relay signals back to Earth, meaning that landers, rovers and other orbiters no longer need to carry the expensive, bulky pieces of kit that were once needed.

ESA has funded the Pathfinder, which is being made by Surrey Satellite Technology Limited (SSTL), in Guildford. ESA will also be the Pathfinder's first customer.

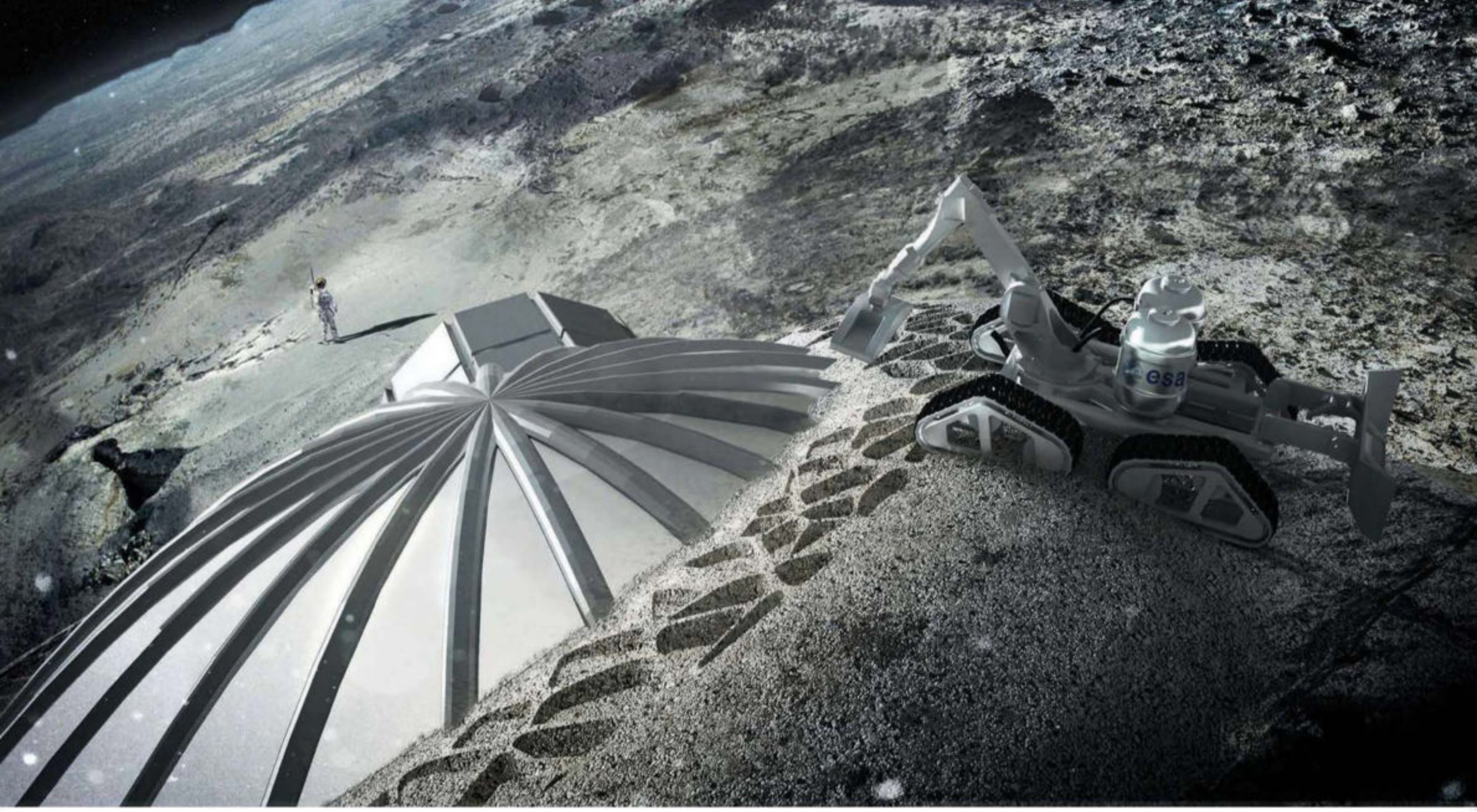
Pathfinder is scheduled for launch in 2023. Once it's up and running, the next step being considered by ESA is a constellation of satellites around the Moon that can also provide the lunar equivalent of GPS. "The idea is to have a number of satellites that will allow enhanced communications coverage of the Moon and high reliability navigation services," says Nelly Offord, the business line manager for exploration and head of lunar services at SSTL.

Of course, it's all well and good providing a satellite that can beam messages back from the Moon, but you then need a ground station to receive them. This is where the once defunct Goonhilly Satellite Earth Station in Cornwall comes in. ❯

ABOVE The ESA-funded Lunar Pathfinder is being built by Guildford-based Surrey Satellite Technology Limited. It will orbit the Moon, relaying signals from lunar landers, rovers and orbiters back to Earth

LEFT The Goonhilly Satellite Earth Station in Cornwall was established in 1962 before becoming defunct. It's now been brought back to life and upgraded to aid with ESA missions

LEFT INSET Sue Horne develops the UK's strategy for space exploration at the UK Space Agency



ABOVE The Moon does not have Earth's protective atmosphere, so any lunar base would need to keep occupants safe from harmful radiation

Situated on the Lizard peninsula on the southern coast of Cornwall, Goonhilly was established in 1962 to receive signals from the experimental telecommunications satellite Telstar. Over the ensuing decades, the site grew into the world's largest satellite ground station before gradually becoming obsolete.

In 2011, the rebirth began when a private company named Goonhilly Earth Station Limited leased the site from British Telecom and began to refurbish the antennas. Now, almost a decade later, the site has attracted money from the Cornwall Local Enterprise Partnership fund and from ESA to help with the upgrading of the antennas, which were in a rather sorry state.

"One antenna had a tree growing through it," says Matthew Cosby, Goonhilly's director of space engineering.

Now, Goonhilly is poised to provide additional coverage for ESA's deep-space tracking system, called ESTRACK. In particular, the Cornish site will be receiving data from some of ESA's older missions, such as Integral, Gaia and Mars Express. It will also be the ground station for SSTL's Lunar Pathfinder.

WORLD PLAYER

Beyond ESA, there could also be another big customer on the horizon. It is no secret that the US is pushing hard to get back to the lunar surface. With the Artemis programme, the White House has set NASA a deadline of 2024 to have boots on the Moon. This represents a considerable acceleration of the more realistic goal to land by 2028, and it is clear that not even NASA has the money or the workforce to make it happen by itself. While NASA is turning to US industry for help, particularly in building lunar landers, the space agency is going to have to turn to international partnerships to get other things done.

Offord thinks that providing reliable high-quality communications is one area in which ESA and the UK could help. "NASA is very interested in using our services, and ESA is right now talking to them about which missions we could support," says Offord.

To stay ahead of this particular curve, Cosby is the UK's representative on the Consultative Committee for Space Data Systems (CCSDS). This is where the standards for spaceflight communications are discussed and agreed, including the communications protocols for NASA's 2024 lunar landing. Everything he learns is implemented at Goonhilly and across the UK, so that if the call comes, they will be ready to jump straight in and relay those historic images – just as Goonhilly was used back in the 1970s to relay images and data from the original Apollo Moon landings.

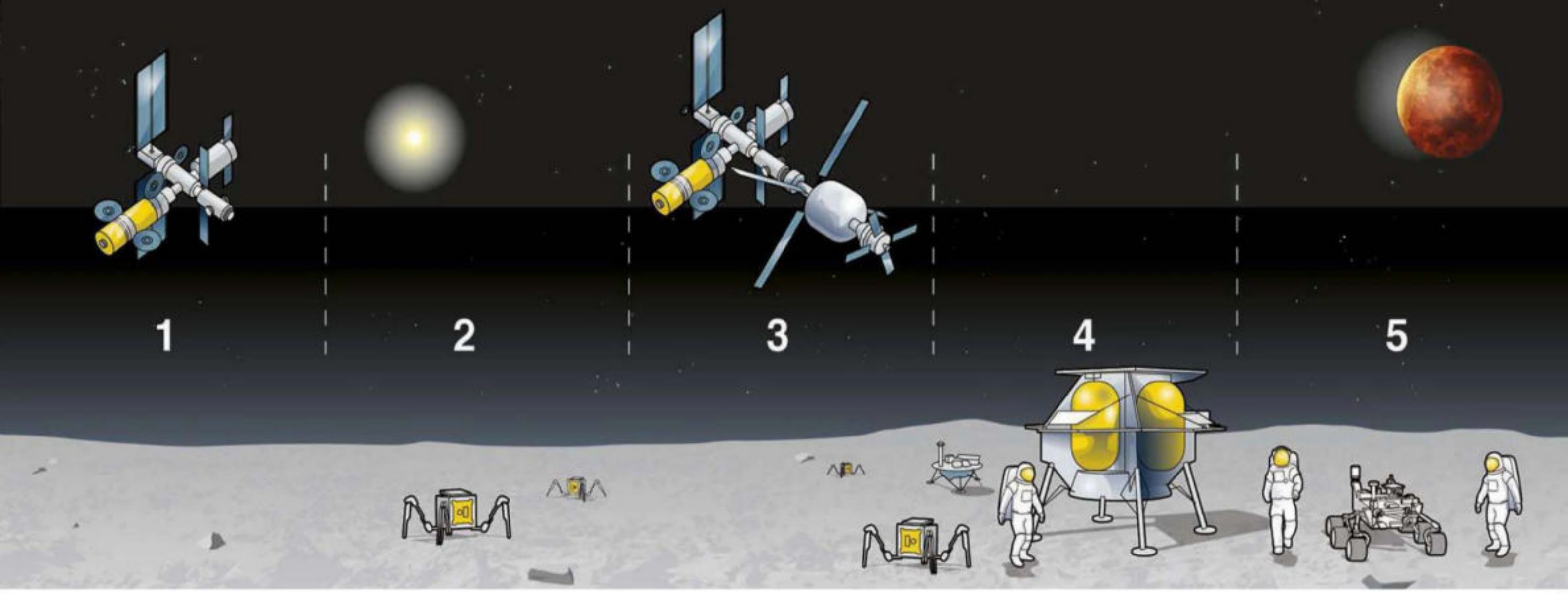
Although NASA and ESA are the only real customers in town at the moment, it may not be long before

> "THE OBJECTIVE IS TO TAKE HUMANS TO MARS. BUT TO DO THAT, WE NEED TO USE THE MOON AS A TESTBED"

FROM THE MOON TO MARS

The new exploration of the Moon is a test of techniques and technology for the larger international endeavour of going to Mars. While it is difficult to put absolute timescales on this endeavour because budgets are being worked out as each country goes along, it is possible to say roughly what the stages will be before humankind is ready to launch a Mars mission.

1 First missions test landing and ascent capability on the Moon.
2 More missions extend the range of tasks performed on the lunar surface.
3 The lunar station is extended to allow more astronauts to live and work around the Moon.
4 A permanent lunar habitat is established, allowing longer stays on the surface
5 Extended stays on the lunar surface or between nine months and a year begin to reach the time needed for a mission to Mars.



ESA/FOSTER AND PARTNERS ILLUSTRATION: ACUTE GRAPHICS

private companies are looking to buy communications services too. Take Tanasyuk's Spacebit: next year's mission with the spider robot is just the first of a rolling programme of increasingly complex missions for the asagumo. Depending on where they touch down, the first mission may or may not reach a lava tube. Instead, the asagumo will be used to demonstrate the spider robot technology. "It will take selfies, do some science and distribute the data to schools and universities for free," says Tanasyuk.

It is a time-limited mission, however. Asagumo is solar-powered and when the Sun sets on the Moon, it takes a fortnight to reappear. In that time, the tiny asagumo, which can fit into the palm of a hand, will have frozen forever. So the first mission will only last about one week.

For their second mission, Spacebit is designing a carrier, into which a number of asagumo will be able to climb. The mothership will be much larger and able to sustain the spider robots for the duration of the lunar night. At dawn, they will crawl back outside and continue their exploration.

If all goes well, for Spacebit's third mission, the carrier will be taken from orbit to the lunar surface on a lander of the company's own making. And this is really where Spacebit's future lies. "We are the only company not only in the UK, but in the whole European region to be designing and working on a lunar lander," says Tanasyuk. The idea is to corner at least part of the lunar transportation market.

There can be no doubt that through the coordination of the UK Space Agency, companies and organisations across the UK are positioning themselves to play key roles in returning humans to the Moon. And as exciting as that is, Horne makes it clear it is also a dress rehearsal for something much larger: human missions to Mars.

"The long term objective is to take humans to Mars. But to do that, we need to use the Moon as a testbed. We need to test out technologies and capabilities," says Horne.

In the 1960s, the UK flirted with the idea of becoming a space-faring country. It built the Black Arrow rocket and launched the Prospero satellite into low-Earth orbit. Then the country turned its back on the endeavour. Now it appears that there is a renaissance of interest in space in the UK. And with companies like Spacebit, SSTL and Goonhilly Earth Station Limited, it seems there is no shortage of individuals and organisations ready to accept the challenge. **SF**

by **DR STUART CLARK** *(@DrStuClark)*
Stuart is an astronomer and science writer. His new book, Beneath The Night *(£14.99, Faber), will be released in October.*

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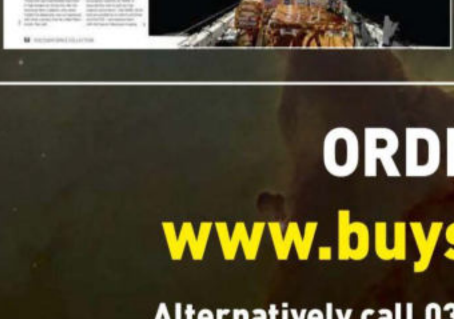
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COMMENT

THE JOY OF A ROUTINE

It might be boring, but setting a routine can reduce stress, ease anxiety and help you sleep

Our lives have all been disrupted by COVID-19, resulting in a big surge in anxiety and issues of mental health. A recent study, carried out by researchers from the University of Exeter, delivered some stark findings. The team used data collected from nearly 12,000 people who, for many years, have been asked questions about their mental health, and found that almost a quarter of respondents reported experiencing at least one mental health problem during lockdown – up from 10 per cent in pre-crisis times. As they put it: "The scale of this deterioration in mental health is of a magnitude unlike anything we have seen in recent years."

One way to cope with the challenges this crisis has thrown up is to find a routine and stick to it. The temptation, when you are stressed, is to watch box sets and eat comfort food (and a survey carried out by King's College, London, found that almost half the population have been doing just that during the lockdown). Though that may feel like what you want to do, in the long term it won't do you any favours.

I feel strongly that, from the point of view of your mental health, ensuring you are getting enough quality sleep should be a priority, and when it comes to sleep it is essential that you establish a routine. You should start by setting a 'sleep window' – the time within which you are planning to sleep – and try to stick to it as closely as possible, seven days a week.

> **"The temptation, when you are stressed, is to watch box sets and eat comfort food"**

I aim to be in bed before 11pm and up at 7am. The first thing I do when I wake is to open the curtains and get a good dose of early morning light. This is important for resetting your internal body clock, which drives so much of what your body will do over the course of the next 16 hours.

After that, I do some resistance exercises, like squats and press-ups. I know that if I don't do them first thing then I will almost certainly not get round to doing them at all. Resistance exercises build and preserve muscle, something that is particularly important as we age. Studies suggest that after the age of 30, people who don't exercise lose up to 5 per cent of their muscle mass every decade. As well as making sure you look good on the beach, doing plenty of resistance exercise has been shown to be a great way of improving sleep quality. At the start of lockdown I could do around 25 press-ups in one go, now it is 45. Which considering I am now 63 is pretty good going.

Other routines that I try to stick to include going for an early morning walk (to get more light) and finishing my evening meal by 8pm so I get in at least a 12-hour overnight fast every day. With a few routines in place, my body stays happy, which helps reduce stress in these challenging times. **SF**

MICHAEL MOSLEY

Michael is a writer and broadcaster, who presents *Trust Me, I'm A Doctor*. His latest book is *Fast Asleep* (£999, Short Books).

BBC TWO

PORTRAIT: KATE COPELAND ILLUSTRATION: JOE WALDRON

COMMENT

THE WAR IN OUR HEADS

In these strange times, it can be tough to get definite answers. To compensate, our brains seek solace in conspiracy theories

ALEKS KROTOSKI

Aleks is a social psychologist, broadcaster and journalist. She presents *The Digital Human*.

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PORTRAIT: KATE COPELAND ILLUSTRATION: SCOTT BALMER

The human brain loves patterns. It's built to make one and one equal two, and to see inappropriate things in Rorschach tests. Psychologically speaking, we lean on patterns as a way to make light work of a world of random stimulation. So when things don't add up, we feel uncertain. Our response is to look for anything to avoid the dissonance of not knowing where we stand.

Welcome to our COVID-19 world. We don't know what's going on right now. Nobody does. There are a lot of incredibly smart people doing some hardcore detective work to get to the bottom of this pandemic, but in the meantime, the rest of us are on the receiving end of conflicting messages from all sides.

When it comes to the kind of uncertainty we are trying to comprehend right now, there is literally a war going on inside our heads. In one corner is the prefrontal cortex, the part of the brain that's rationally gaming out the possible outcomes. In the other corner is our amygdala – the bit that controls fight or flight – and it is sprinting towards anything that feels right, and away from anything that feels threatening. It's looking for simple solutions. Unfortunately, that's exactly what we should be avoiding.

Dr Charles Morgan is a professor of national security at the University of New Haven, Connecticut. He has been studying extreme uncertainty for more than four decades, working with active duty special forces soldiers who spend a lot of time in what everyday people would categorise as 'extreme stress'. Charles – or Andy as he's known to anyone except his mum – is an affable chap with an interest in what makes our brain chemistry tick.

> "Our amygdala is sprinting towards anything that feels right, and away from anything that feels threatening"

According to a 2013 paper from Andy and his colleagues at Yale, the US Navy and the University of California, we're more likely to believe (and in the age of social media: rapidly spread) things that are untrue.

What's happening, he thinks, is that exposure to high states of anxiety and stress make it easier to create a false memory. Our critical thinking drops out. We become dominated by the primitive amygdala, which bypasses misinformation past our prefrontal cortex and fills in whatever gap doesn't make sense in our internal story.

Think about it: if you are looking for a pattern, a conspiracy theory is like a box of free sweeties. Our brains would prefer to think some evil person out there is doing all this, because it means that someone is actually in charge. And that makes us feel better. Because stuff isn't random any more. And now we know who to blame.

How do we tame the amygdala? We invoke the adult part of our brains to tame the impulsive child. And to do that, we need to create routine. We administer self-care. We start on the path that leads us to understand that the control we think we have over our world is a facade. This pandemic is an opportunity to reassess where we stand. SF

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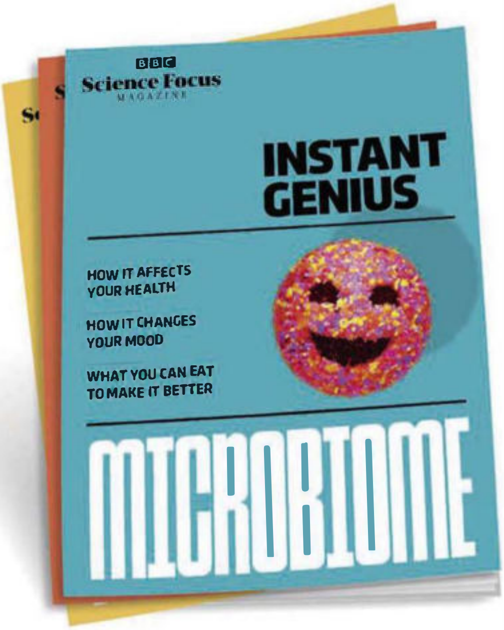
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LOOKING FOR LIFE ON MARS

The Mars 2020 Rover, named Perseverance, is set to launch this month. It will collect rock and soil samples from our red neighbour, which **Miché Aaron** will be using in her search for organic minerals. She tells **Amy Barrett** how the presence of these minerals could reveal if there was once life on Mars…

WHAT MINERALS ARE THERE ON MARS?

There are silicates, which basically contain silicon and oxygen atoms, along with magnesium, iron or calcium. Depending on the silicate, they can either be arranged in sheets, layered flat, like a flaky pastry; or globular, like people would expect a rock to look. Other minerals we have are iron oxides – the reason why Mars is red. Haematite is one of the most common iron oxides that you'll see on Mars and on Earth too. We call it haematite because it's red like blood [the word 'haematite' is derived from the Greek for 'blood'].

Then there are things like sulphates, oxalates and carbonates, and I'm sure there are others that I haven't named. Carbonate is the one that many scientists want to find, for the same reason that I want to find oxalates: because of the association with life.

WHAT ARE OXALATES?

You actually might be more familiar with them than you think. If you've heard of kidney stones, that's calcium oxalate.

Oxalates are organic minerals, and they're often associated with living organisms, although they can form through abiotic [non-biological] methods. On Earth, they primarily form through biological processes in plants or animals. So, they have a strong association with life on Earth, and they're really exciting because they're known to be stable on the surface of Mars. They can exist in extreme environments. And when I say extreme, I mean environments in which a human wouldn't thrive for very long, without some sort of mechanism to keep them alive. Think of places like Antarctica, or the Atacama Desert – those are actually two good analogue sites for Martian research.

Oxalates are also high-value targets because they have the potential to preserve biological activity from past and present Mars. ▶

> "Oxalates have a strong association with life on Earth, and they're really exciting because they're known to be stable on Mars"

WILL KIRK/JOHNS HOPKINS UNIVERSITY

> “When learning about space exploration, all I saw were white men. I don’t think I was even exposed to Mae Jemison”

SO IF OXALATES ARE FOUND ON MARS, IT COULD MEAN THERE’S LIFE THERE?

Well, not necessarily, because oxalates can also form through this [non-biological] process called diagenesis, which is when a mineral is physically and chemically changed by increases in temperature and pressure, or through hydrothermal [hot water] processes.

On Earth, these changes in temperature and pressure happen after sediments rich in organic matter are deposited and buried. There they are reheated and they experience more pressure, to the point that their molecular structure changes. Then, when they come back up to the surface, it’s in a different form, similar to metamorphic rocks.

Now, we don’t see surface uplifting on Mars because as far as we know Mars doesn’t have tectonic plates. So there is no mechanism for rocks formed through metamorphism, much less diagenesis, to resurface.

Yet we do have metamorphic rocks on Mars, and can witness diagenesis by analysing rock layers along the sides of craters. That, we believe, is due to meteorite impacts because that is the only thing that can cause that high amount of pressure and heat to do that process. These meteorites, or to be more specific, these carbonaceous chondrites, contain an acid called carboxylic acid. That carboxylic acid actually bonds with other substances to create oxalates.

So, if I were to detect oxalates on Mars tomorrow, would I be able to say that, yes, there is life on Mars right now, or there was life on Mars? That there was vegetation? That there were mushrooms? No, I couldn’t, because whenever I collect that information, it’s hard for me to determine how they [the oxalates] formed.

HOW DO YOU DETECT MINERALS ON MARS?

I use something called remote sensing, which is where an instrument collects information from the surface of the planet in the absence of physical contact. I use infrared spectroscopy. Spectroscopy is the study of light, and how light interacts with an object. Infrared can produce vibrational properties when it interacts with a mineral’s molecular structure. The distinct patterns made by each mineral group are like a fingerprint that we can use to help identify the minerals on Mars.

Mars is pretty far away from Earth, so it takes some time for large quantities of data to get transferred here. And when that happens, we generally get raw data, which is unprocessed, and can often contain artefacts – basically things that can inhibit a person from properly analysing the data. So, for example, with my datasets I often have to make atmospheric corrections, because unfortunately Mars is very, very dusty. That dust interferes with our data.

In-situ [on-location] spectroscopy with the rovers is actually the best way to analyse rocks on a different planet, as there is no atmospheric interference. I’m not currently using rover data because I’m still relying on satellite imagery to get a good idea of which location has oxalates. I know one of the locations is Jezero Crater, which is where the Mars 2020 Rover, Perseverance, is going to land. Perseverance is scheduled to launch this month, on 20 July. Do you understand the significance of that day?

I DON’T.

That was the day that Apollo 11 landed on the Moon. So last year, we had the 50th anniversary for the Moon landings. I just think that it’s really cool that was the date picked for it.

HOW DID YOU COME TO BE LOOKING FOR EVIDENCE OF LIFE ON MARS?

My grandparents took me to space camp at the Space Center in Houston every summer from the age of around eight until I was 13 and I aged out. That was when I was first enamoured by anything related to space. We built rockets, we met astronauts, we learnt about the Space Shuttle programme – I still tear up whenever I see the Space Shuttle launch on video. And even though

MICHÉ AARON

After studying planetary geology at Wesleyan University, Miché started a master’s in geographic information systems (GIS) at Sam Houston State in Texas. After getting her master’s, she began working at Carnegie Geophysical Laboratory, researching oxalates. From there, she got connections with people at Johns Hopkins Applied Physics Laboratory and progressed her research using remote sensing. She is now studying for a PhD at Johns Hopkins. Miché went viral on Twitter when she posted a list of resources to help underrepresented students get information on degrees, scholarships, fellowships, funding applications and mentoring opportunities. She also helped set up the Woman of Color Project, a programme that helps women of colour in STEM apply to and thrive in grad school.

WILL KIRK/JOHNS HOPKINS UNIVERSITY

we basically did the same stuff every summer, at the end of the programme I'd always tell my grandparents, "I want to work at NASA when I grow up."

I was just fascinated by the stuff that's out there, the galaxies, planets, stars… My grandparents got me a telescope, so I was able to explore it [space] from the comfort of my home.

Eventually, I decided that I wanted to major in astronomy and physics. I went to Wesleyan University for my undergraduate degree, and I was introduced to Dr Martha Gilmore, who is in the earth and environmental science department. She's a planetary geologist, who primarily focuses on Venus and Mars, and also, she is a black woman. I'd never met a black woman who studied this stuff. And it was just amazing. So, she became, and still is, my mentor – you don't really retire out of that.

She taught me a lot about Martian spectroscopy and remote sensing, and she allowed me to do research with her looking at minerals on Mars.

WHY DOES REPRESENTATION MATTER?

I grew up partly in Louisiana and in Houston, and I did have black mentors growing up, I had teachers that were black. But with regards to learning about space exploration, all I saw were white men.

I don't think I was even exposed to Mae Jemison [the first black woman to travel into space], which is kind of sad. I only knew about her once I went to college.

It's not that I didn't think that I would see a black woman in my field. I was just excited to see one in my field because it gave me the message that if she can do it, I can do it. And it was definitely one of the factors that kept me in the field. Of course, it was also the love of mineralogy and spectroscopy that kept me here.

This is actually one reason why representation is so important in STEM, especially for little black boys, little black girls or any other child that's an underrepresented minority. When they get into a field that's been run predominantly by white men, they want to see someone that looks like them.

Of course, the field is going to be very difficult, race aside, because this is a complex topic. But seeing someone there who looks like you, and they went through the fire, came on your side, and they're well-respected and well-known in their field – it gives you hope. **SF**

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What pop psychology gets wrong

WORDS **DR CHRISTIAN JARRETT** ILLUSTRATION: **JAMES MINCHALL**

Power corrupts, crowds are violent and depression is just a chemical imbalance. Right? The classic psychology theories often have a nice ring to them, creating a mythology that persists throughout the media, cinema and literature. But new research is revealing that the human mind isn't as simple as we'd like to think…

ILLUSTRATION: JAMES MINCHALL

When eye-catching theories emerge in the field of psychology, they often take on a life of their own. Just look at the idea that oxytocin is the 'cuddle hormone'. This captures our imaginations, but research has shown that oxytocin can also increase feelings of intolerance and aggression. We are all amateur psychologists, and the field provides an appealing way for us to make sense of our feelings and behaviour. If it can confirm our own beliefs about human nature, then even better. But just like every science, psychology is a messy, ongoing process, and many headline-grabbing results have not been replicated, or are far more nuanced than first realised. Here are eight widely believed pop psychology ideas that are probably wrong, or at least overly simplistic.

"POWER ALWAYS CORRUPTS"

Does evil reside within us, or are we corrupted by circumstances? In 1971, the Stanford University psychologist Philip Zimbardo sought to demonstrate the potential power of situations and social roles to corrupt individual morality. Anticipating the scenarios dreamt up by reality TV decades later, Zimbardo and colleagues created a mock prison and recruited 12 male college students to play the role of guards and 12 to play the role of prisoners. The idea was to study their interactions for two weeks, but the 'Stanford Prison Experiment' had to be aborted after just six days, such were the levels of cruelty perpetuated by the 'guards' upon the 'prisoners', including forcing them to clean toilets with their bare hands.

To Zimbardo, the shocking lesson was clear – powerful situations can overwhelm our individuality, turning good people bad. His interpretation chimed with ideas about the roots of evil, apparently helping to explain atrocities of the past, and future – Zimbardo would later invoke his research while testifying in defence of one of the US guards accused of cruelty towards prisoners at the Abu Ghraib prison in Iraq in 2003-4.

Over the years, Zimbardo's study has been subject to intense criticism and reinterpretation. In 2002, the British social psychologists Alex Haslam and Stephen Reicher conducted a similar experiment called the 'BBC Prison Study'. In their version, the prisoners united and overthrew the guards, showing that the events of the Stanford experiment were far from inevitable. Footage has also emerged of Zimbardo – in the role of 'prison superintendent' – instructing his guards on how to behave, which seems to undermine the spontaneity of the events that unfolded. More recently, an audio recording was uncovered that revealed one of Zimbardo's collaborators, in the role of 'prison warden', persuading one of the 'guards' to treat the prisoners more cruelly, including telling him that, if he did a good enough job, the experiment could lead to real-life prison reform. Critics like Haslam say the recording shows the Stanford study was more akin to a form of live theatre than a science experiment. Zimbardo and his defenders counter that, whether the guards' sadism was inevitable or not, the study's message still holds – that, in the wrong circumstances, otherwise 'normal' people are capable of extreme cruelty.

"His interpretation chimed with ideas about the roots of evil, apparently helping to explain past atrocities"

“CHILDREN WITH MORE WILLPOWER ARE MORE SUCCESSFUL IN LATER LIFE”

In the 1960s, the American psychologist Walter Mischel began a series of iconic experiments that involved challenging several dozen young children to sit alone with a marshmallow for around 15 minutes and resist eating it. Their reward, if they waited, was to eat the first marshmallow, plus another. Famously, the researchers caught up with the same kids in the 1980s and 1990s, by which time they were adults, and found that those who'd been successful at this ‘delayed gratification’ task had subsequently done better in life, in terms of exam results and avoiding getting into trouble. The results appeared to suggest that if we could teach kids to have stronger willpower, their lives would benefit.

However, in 2018 psychologists at New York University and the University of California, Irvine, conducted the first replication attempt of the marshmallow study, but this time using data from hundreds of children. Unlike in the original research, Tyler Watts and his colleagues also controlled for a host of social and situational variables, such as parental educational background and how responsive parents were to their kids. The team found that correlation between delay of gratification and later success (in this case in adolescence) was far weaker than in the original research. Moreover, the correlations became statistically non-significant when the researchers factored in the social and family variables.

Watts and his colleagues' interpretation was that a child's ability to resist the marshmallow has less to do with their inherent willpower, and more to do with their family circumstances – for instance, whether the child had learned to trust being promised greater rewards in the future or not. This chimes with other research that's found that adults succeed at their goals through forward planning and avoiding temptation, rather than through brute willpower. ➲

ALAMY ILLUSTRATION: JAMES MINCHALL

"CROWDS MAKE PEOPLE MINDLESS AND VIOLENT"

Media accounts of riots often imply that a mob mentality has taken over. Such reports reflect a commonly held belief that when large groups of people get together, people lose their individual morality and run amok with the herd. Similarly, newspaper reports of disasters often describe crowds as if they are mindless, with talk of 'stampedes' and blind panic.

The reality, according to many contemporary social psychologists, is that there is a logic and purpose to much crowd behaviour. Violence is far from inevitable when large groups assemble – just look at the restraint shown on American civil rights marches in the 1960s. Even in the case of rioters, while they might often be violent and destructive, they usually have a shared purpose and a clear sense of identity. During the English riots of 2011, for example, the damage was aimed mainly at targets seen as symbolising inequality, such as high-end shops. Also, it wasn't the case that anyone who saw the riots on television, or encountered them in the street, was sucked zombie-like into 'the mob' – rather it was in neighbourhoods where there was already a strong sense of disenfranchisement that people were far more likely to join in.

It's a similar story for crowds in emergencies. Analysis of real-life events, such as the Hillsborough disaster of 1989 and the overcrowding at a Brighton beach concert in 2002, suggest that blind panic is rare and that people will often stop to help one another. This altruistic behaviour is perhaps due to a sense of togetherness that's forged as groups of strangers go through a common experience.

"It wasn't the case that anyone who encountered the riots in the street was sucked zombie-like into 'the mob'"

ILLUSTRATIONS: JAMES MINCHALL

"DEPRESSION IS DUE TO A CHEMICAL IMBALANCE"

The most commonly used antidepressant drugs increase the availability in the brain of a chemical called serotonin. Whatever the rights and wrongs of the drugs (some credit the drugs for saving their lives, while critics fear the overmedicalisation of emotional problems that have complex roots), their rising use has fed the notion that depression is caused by some kind of chemical imbalance in the brain that requires correction.

The reality is that most psychiatrists believe that the chemical imbalance idea is a gross oversimplification. Part of the issue is that it's based on flawed logic. Just because these drugs increase serotonin levels, it doesn't mean that a lack of serotonin is the cause of depression (after all, your headache is not caused by a lack of paracetamol). Beyond that, post-mortem research has failed to show that people with depression have lower levels of serotonin, and studies that have artificially lowered people's serotonin levels have not induced depression. The truth is that there is no psychiatrist or neuroscientist who could honestly say what the healthy or correct levels of brain chemicals should be.

Many mental health campaigners have embraced the chemical imbalance idea, believing that it will help to reduce stigma by showing that depression has a clear physical cause. Sadly, if anything, biological explanations of mental illness seem to have increased stigma, perhaps because they cause people to perceive mental health conditions as being more fundamental to the sufferer and more difficult to treat.

"FIRSTBORNS ARE NATURAL LEADERS"

What do Emmanuel Macron, Angela Merkel and Boris Johnson have in common? How about Jeff Bezos and Elon Musk? They are all the eldest among their siblings – providing anecdotal evidence to back up the popular idea that firstborns have distinct personalities that help them become leaders. This rationale has a logical appeal – after all, the eldest child enjoys the undivided attention of their parents for a time, after which they get to boss their younger siblings around.

However appealing this pop theory, the evidence largely doesn't support it. In 2015, when psychologists carefully analysed the personality traits of hundreds of thousands of people and then correlated them with people's birth-order position in their family, no clear associations were found. A subsequent Swedish study did find that firstborns were more likely to end up in leadership roles, but the correlation was weak. If there is a link, then it probably has more to do with opportunity than aptitude, such as being the one chosen to take over the family business.

"WE ALL HAVE A PREFERRED LEARNING STYLE"

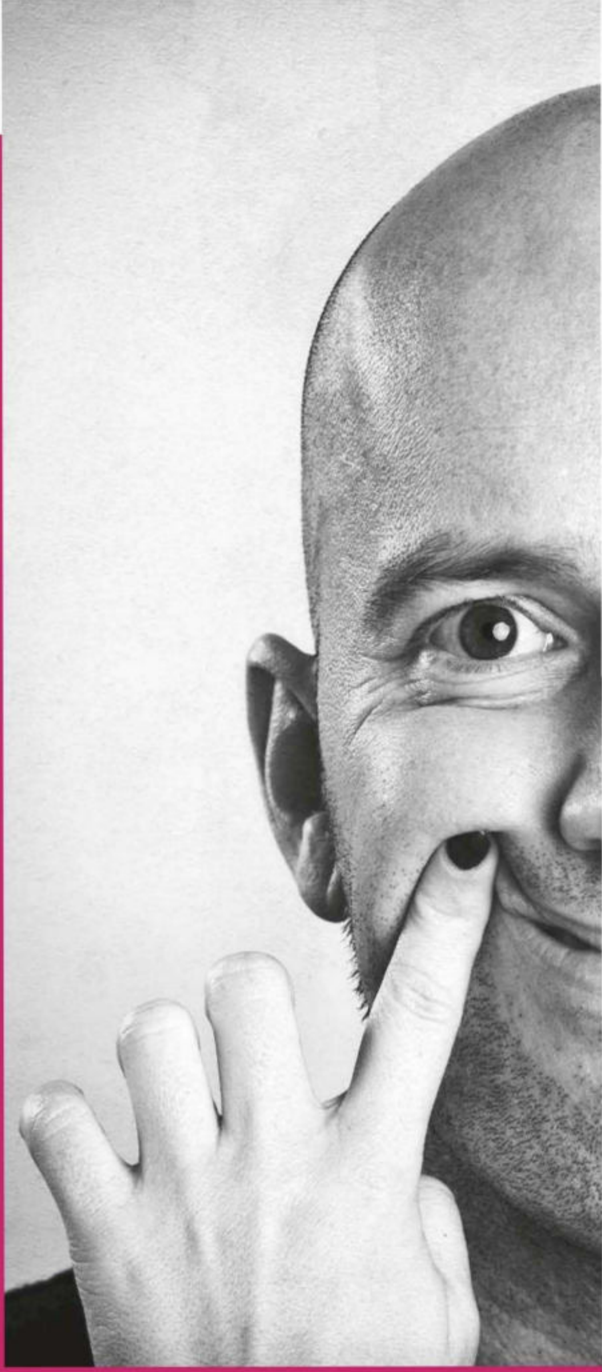
Do you find it easier to learn by reading an article or listening to a podcast? Maybe you prefer images over text? Surveys suggest that most of us believe we have a preferred 'learning style', be that visual, auditory, kinetic (learning by doing), or something else. A majority of teachers believe it, too. In fact, a whole industry has built up around finding ways to measure people's learning styles and guiding teachers on how to teach to those different styles. However, this is probably the most striking example of where folk wisdom clashes with psychological science. Time and again, carefully controlled studies have failed to find evidence to support the 'learning styles' approach.

Most studies in this area follow a similar format – volunteers report their preferred learning style, and then some of them are presented with material in their favoured modality while others are not. A test then ensues. Nearly every study has found that those who learn via their preferred style do not perform any better than a comparison group not taught to their preference. What's more, participants rarely show much insight into their supposed best learning style – their performance is often better in their non-favoured methods.

Critics of learning styles point out that the optimum way to teach often depends on the nature of the topic, not the preferences of the individual students. Others say that even if you do have a weakness in learning a particular way, it is better if teachers help you improve in that area, rather than avoiding it.

> "The optimum way to teach often depends on the nature of the topic, not the preferences of the individual students"

"SMILING WILL MAKE YOU FEEL HAPPIER"



The roots of this idea date back to Charles Darwin's 'facial-feedback' hypothesis, which proposes that the outward expression of emotions can feedback and affect our feelings. Esteemed 19th-Century philosopher and psychologist William James proposed a similar idea – that it's the physical changes associated with fear that lead you to feel afraid, not the other way around.

These theories inspired a 'modern classic' of psychology, published in 1988. Researchers led by psychologist Fritz Strack asked volunteers to watch cartoons, either while holding a pen between their teeth, thus forcing a smile, or with the pen held between their lips, forcing a frown. The smilers found the cartoons funnier, suggesting that the mere act of grinning could have a positive effect on feelings. This result, and later variations, soon led self-help authors

to propose that you could simply smile your way to greater happiness.

But in 2016, a collective of 17 separate research labs recruited nearly 2,000 participants in an attempt to replicate the cartoon study. The findings were inconsistent across the labs, and when they were pooled together, the result was a negative – smilers were no more amused than frowners.

However, it may be premature to write off the facial-feedback theory. Strack pointed out that the modern replications videoed the participants, whereas he hadn't, which might have interfered with the results, perhaps by making participants self-conscious. Also, other research findings, such as those involving Botox patients, are consistent with the facial-feedback hypothesis. Botox treatment interferes with facial expressions, and those who've had it seem to experience emotions differently from other volunteers.

GETTY IMAGES ILLUSTRATION: JAMES MINCHALL

"OXYTOCIN IS THE 'CUDDLE HORMONE'"

Especially around Valentine's Day, the popular media gets excited about oxytocin, often referred to as the 'love hormone'. It's absolutely true that this chemical is released in the brain when women give birth and breastfeed, and also when people cuddle and have sex – hence the media nicknames. There were also studies conducted in the early 2000s that suggested sniffing oxytocin made people more trusting, generous and better at empathising with others. Subsequently, the molecule has been mooted as a breakthrough intervention for various conditions, from autism to schizophrenia.

If it all sounds too good to be true, that's because it is. More recent research has questioned those early findings on the chemical's effects, both failing to replicate them and painting a more nuanced picture. For instance, while oxytocin might increase feelings of bonding with friends and family, it can also sharpen dislike for outsiders. It can even heighten aggression in those with violent tendencies. In short, oxytocin is certainly an intriguing chemical, but it's far more than a cuddle hormone. **SF**

by **DR CHRISTIAN JARRETT**
Christian is the author of Great Myths Of The Brain *(£15.99, Wiley Blackwell). His new book on personality change will be published next year.*

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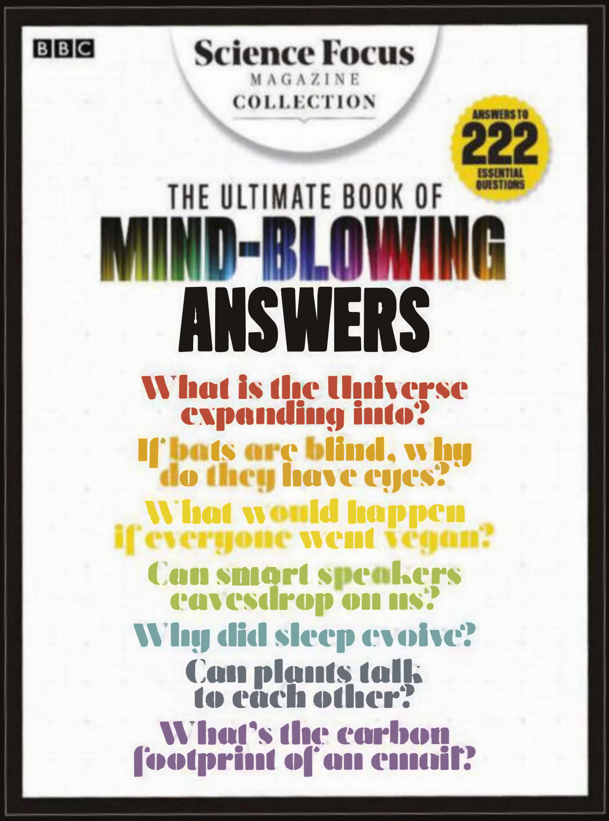
ANSWERS TO 222 ESSENTIAL QUESTIONS



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Q&A

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... HOW MANY STARS ARE IN THE MILKY WAY?
... HOW DID TORTOISES REACH THE GALÁPAGOS ISLANDS?
... WHAT CONNECTS CORNED BEEF AND THE *TITANIC*?
... DO SUBATOMIC PARTICLES HAVE A COLOUR?
... WHY DO WE HAVE DIFFERENT BLOOD TYPES?
... WHY DO ICE CUBES CRACK WHEN YOU PUT THEM INTO WATER?
... WHAT IS THE 'GOLDILOCKS ZONE'?
... CAN YOU RECYCLE PLASTICS AN INFINITE NUMBER OF TIMES?
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ILLUSTRATION: DANIEL BRIGHT

BARRY EVANS, CARDIFF

WHAT'S THE MOST POPULAR DOG BREED?

According to data from the Kennel Club, the Labrador is currently the UK's top dog, reclaiming its spot last year after briefly losing it to the French bulldog. In the US, the Labrador has been the most popular breed for nearly 30 years. Labradors are favourites because they are great all-rounders: they're good-natured, playful and relatively easy to train. They are also highly intelligent dogs – canine psychology expert Dr Stanley Coren ranks them as one of the 10 brightest breeds – and they have the highest success rates for passing training programmes to become guide dogs. Labradors also have fewer health complications than many other breeds. They typically live for around 12 years, although a 2018 study at the University of London's Royal Veterinary College found that chocolate Labs have 10 per cent shorter lifespans, due to greater inbreeding. Probably the most common health issue that Labradors face is obesity. This isn't just greediness: a 2016 study at Cambridge University reported that 25 per cent of Labradors have a genetic mutation that means they never feel full. ***LV***

DEAR DOCTOR...

DELICATE ISSUES DEALT WITH BY *SCIENCE FOCUS* EXPERTS

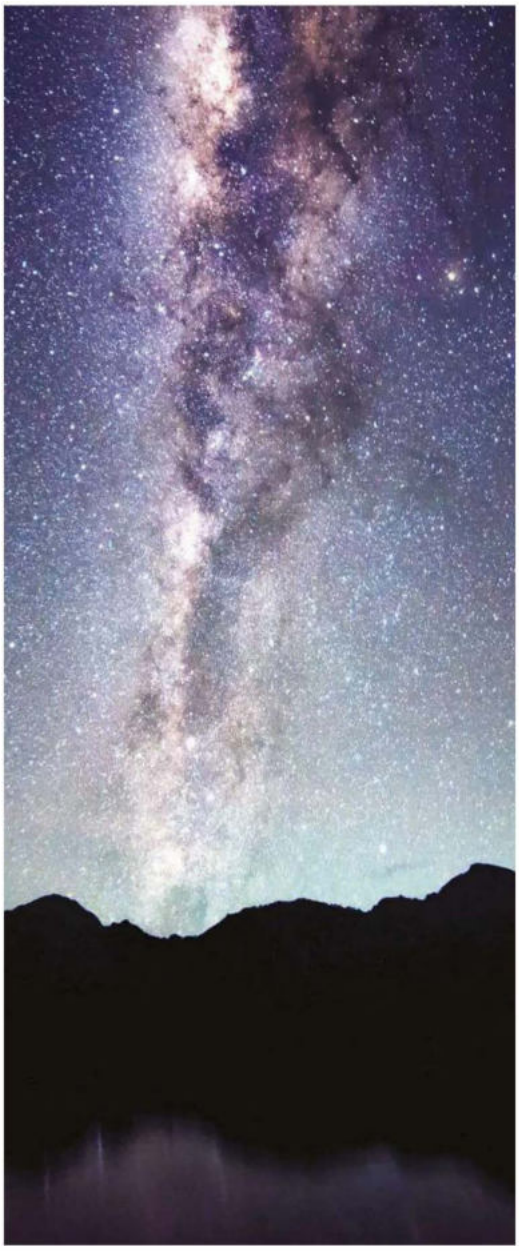
I'VE BURNED MY HAND ON THE OVEN AND MY FRIEND SAYS I SHOULD PUT HONEY ON IT. IS SHE BEE-ING SERIOUS?

Don't worry, your friend hasn't lost the plot. Honey has been used for treating wounds, including burn wounds, for thousands of years, as far back as ancient Mesopotamia and Egypt. Today, we know that honey has both antimicrobial and anti-inflammatory properties, and several studies over the last few decades have found that honey can reduce healing times, infection and inflammation, even when compared to conventional wound treatments such as antiseptics.

There are likely to be many mechanisms at play in honey's wound-healing abilities, and we don't know the full story. But we do know that honey stimulates white blood cell production, which triggers tissue repair and regrowth. Honey is also acidic, so it lowers the pH of a wound, which hinders bacterial growth and speeds up healing. Honey's high sugar content is also bad news for bacteria, causing them to become dehydrated, while honey's antioxidants help to reduce inflammation.

Doctors today still use honey-infused dressings to treat wounds, including burns. But you shouldn't use the honey from your cupboard at home without speaking to a doctor first. Medical honey has been sterilised, whereas standard honey contains microbes that could get into the wound and cause problems.

For burns, you're best off putting the affected area under the cold tap for at least 10 minutes, before picking up a gel or dressing at your local pharmacy. Save the honey for your toast instead. ***SO***



SOPHIE WYATT

HOW MANY STARS ARE IN THE MILKY WAY?

Astronomers can't be sure about this number, because not all Milky Way stars are visible from the Earth, due to some of them being too far, too faint, or obscured by gas or dust. However, various estimates are available: some based on the shape and size of our Galaxy, others based on our Galaxy's likely mass. These estimates typically range from 100 billion to 400 billion stars. For comparison, 100 billion is approximately the number of people who have ever lived on Earth. ***AGu***

GETTY IMAGES X2, NASA ILLUSTRATIONS: DANIEL BRIGHT

TAMSIN NICHOLSON

HOW DID TORTOISES REACH THE GALÁPAGOS ISLANDS?

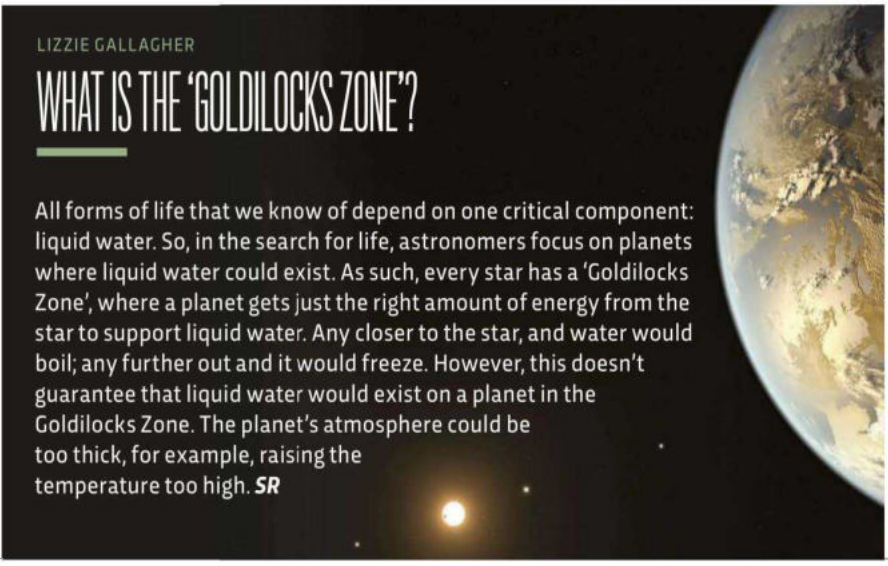
The Galápagos tortoises are iconic animals, often living for over 100 years and weighing as much as 400kg. They're only found on the Galápagos Islands in the Pacific Ocean, nearly 1,000km away from the nearest landmass, Ecuador. So scientists have long scratched their heads over how they got there in the first place.

In the early 19th Century, some thought that sailors had transferred the giant tortoises to the Galápagos Islands from the Mascarene Islands in the Indian Ocean. However, thanks to DNA tests, we now know that the ancestor of Galápagos tortoises came from South America.

In the late 1800s, palaeontologist Georg Baur thought that the animals must have walked across an ancient land bridge. They couldn't have crossed an ocean, he reasoned, because tortoises were thought to be poor swimmers. But then, in 1923, naturalist William Beebe tossed one over the side of a yacht! Fortunately, the reptile was a skilful swimmer, steering itself purposefully and extending its neck upwards to breathe. But a week after the ordeal, it died. Beebe assumed that it had ingested too much seawater, so he found the idea of a tortoise swimming from Ecuador to the Galápagos just too much to swallow.

In the end, it took two lines of evidence to seal the deal for #TeamSwim. In the mid-20th Century, research on plate tectonics confirmed that the Galápagos Islands were formed by volcanic activity. The islands rose from the ocean. There never was a land bridge. And in 2004, a giant tortoise from Aldabra, in the Indian Ocean, walked onto a beach in Tanzania, Africa, after swimming (and/or drifting) for 750km. It was emaciated and covered in barnacles, but otherwise okay.

Scientists now think that Galápagos tortoises became established after a pregnant female ancestor or breeding pair made a similar long-distance swim from South America to the islands, around two million years ago. ***HP***



LIZZIE GALLAGHER

WHAT IS THE 'GOLDILOCKS ZONE'?

All forms of life that we know of depend on one critical component: liquid water. So, in the search for life, astronomers focus on planets where liquid water could exist. As such, every star has a 'Goldilocks Zone', where a planet gets just the right amount of energy from the star to support liquid water. Any closer to the star, and water would boil; any further out and it would freeze. However, this doesn't guarantee that liquid water would exist on a planet in the Goldilocks Zone. The planet's atmosphere could be too thick, for example, raising the temperature too high. ***SR***

HIDDEN FIGURES

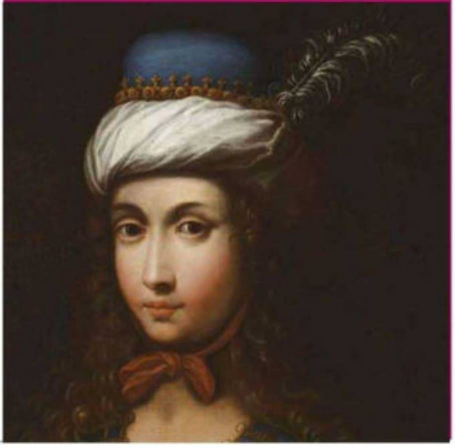
LADY MARY MONTAGU

INTRODUCED SMALLPOX INOCULATION TO THE WEST

The invention of vaccination in the 18th Century is a turning point in medical history. Yet while the English physician Edward Jenner is rightly praised for his role in developing the first vaccine – for smallpox – the key role played by an English aristocrat is often overlooked.

In 1717, Lady Mary Montagu was the wife of Britain's ambassador to Turkey, where she witnessed a strange ritual said to protect against smallpox. It involved smearing infected pus from a smallpox victim into scratches made on those seeking immunity.

With 400,000 dying annually from smallpox in Europe alone, Montagu decided to have her two children treated with the method. She also persuaded leading British physicians to supervise experiments, which showed that the technique did protect against smallpox. The method – now known as 'variolation' – became widely used, although there was still a 1 in 40 risk of the patient contracting the full-blown disease and dying. Not until 1796, over 30 years after Montagu's death, did Jenner – who had himself been 'variolated' as a boy – begin his famous experiments replacing smallpox with cowpox, a related but harmless disease. By 1800, Jenner's safer 'vaccination' method had been widely adopted. Yet Montagu's promotion of variolation was vital in convincing doctors of the idea of protection through deliberate infection. ***RM***



WHAT CONNECTS...

CORNED BEEF AND THE TITANIC?

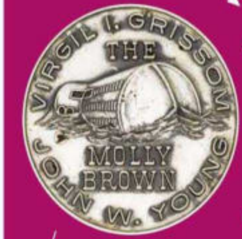
1.

In March 1965, NASA astronaut John Young smuggled a corned beef sandwich onto the Gemini 3 spacecraft. He was reprimanded on returning to Earth, as the crumbs could have damaged the craft's electronics.

2.

During the Gemini 3 mission, Young and crewmate Gus Grissom completed three orbits of the Earth and carried out the first orbital manoeuvre in a crewed spacecraft. They nicknamed their spacecraft Molly Brown.

3.



The name was a playful reference to the Broadway musical *The Unsinkable Molly Brown*. On Grissom's previous mission, he'd had to swim free of his spacecraft *Liberty Bell 7* as it sank after splashdown.

4.

The musical was a fictionalised account of the life of Margaret Brown, a US socialite and philanthropist who was one of the survivors of the *Titanic* disaster in 1912.

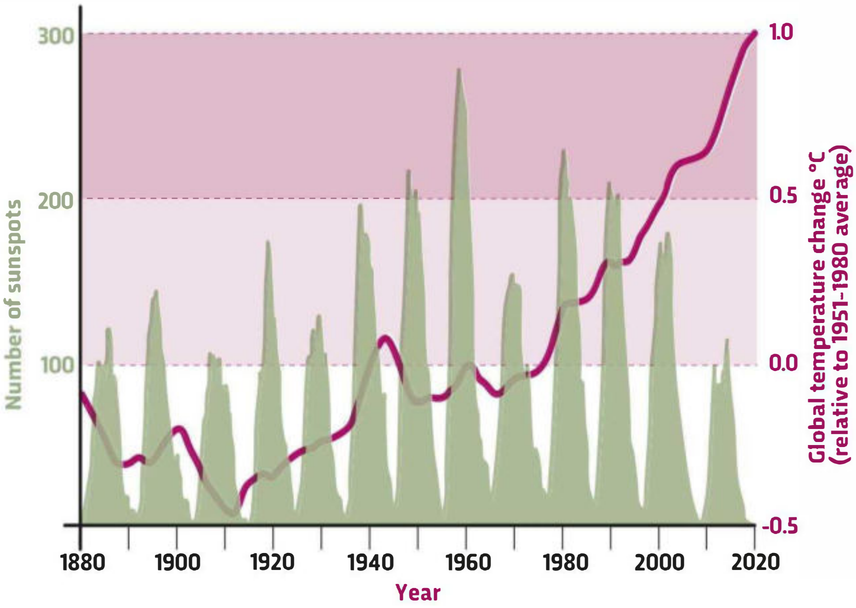
TONY HERSH, NEWBURY

WILL INCREASED SUN ACTIVITY MAKE CLIMATE CHANGE WORSE?

The Sun's activity follows a regular cycle, driven by changes in its magnetic field. Scientists typically measure solar activity by counting sunspots – dark areas on the Sun's surface that form where magnetic fields are strongest. These ebb and flow in a repeating cycle averaging 11 years. In the first half of the solar cycle, magnetic activity progressively ramps up until the 'solar maximum', when the number of sunspots can reach over 200. This is accompanied by an increase in the Sun's energy output. Over the second half of the cycle, solar activity wanes, dipping to the 'solar minimum' before a new cycle begins.

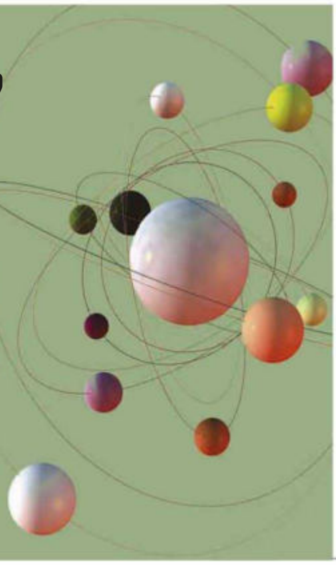
We are currently at a solar minimum, and will therefore see an increase in solar activity between now and 2025. However, even at solar maximum, the energy that the Earth receives from the Sun is only around 0.1 per cent higher than average. This has only a tiny impact on our global temperatures, which pales in comparison with the effect of human-emitted greenhouse gases such as carbon dioxide.

The last three solar cycles have all been weaker than their predecessor, leading some scientists to speculate that we could be about to enter a prolonged period of lower solar activity. But at best this would offset global temperature rise by just 0.3°C, and it would only be a temporary effect until the Sun's activity ramped up again. ***AFC***



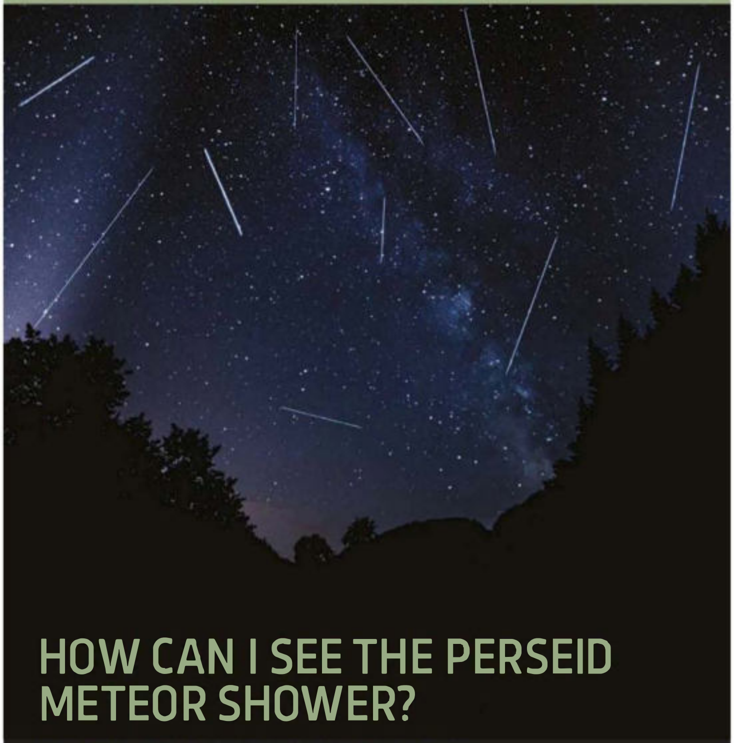
MATILDA WICKS, BRIGHTON

DO SUBATOMIC PARTICLES HAVE A COLOUR?



Colour might seem like an inherent property of matter, but it's actually the result of a process – specifically, how matter interacts with light. In an atom, the electrons orbiting the nucleus absorb the incoming light energy, and jump into higher energy levels. These so-called 'excited states' are unstable, and in returning to their original state, the electrons re-emit certain wavelengths of light, which we see as a specific colour. But a solitary electron – or any subatomic particle – simply mops up the incoming light energy, and thus lacks any specific colour. *RM*

ASTRONOMY FOR BEGINNERS



HOW CAN I SEE THE PERSEID METEOR SHOWER?

WHEN: PEAKS ON 11-13 AUGUST

On any given night of stargazing, you can expect to see about two meteors every hour. Meteors, commonly known as 'shooting stars', are flashes of light caused by pieces of dust or rock burning up as they pass through the Earth's atmosphere. Incredibly, these are usually the size of a grain of sand, but they travel so fast that they create a trail that glows as brightly as the stars.

Every so often, the Earth's orbit brings us into a particularly dense patch of cosmic debris – a trail of rock and dust left in the wake of an asteroid or comet. We see this as a meteor shower.

The Perseid ('Per-see-id') meteor shower is one of the most active in the northern hemisphere, providing up to 100 meteors per hour. Caused by debris from the comet Swift-Tuttle, the Perseids are named after the constellation that the meteors appear to come from: Perseus (astronomers call this point the meteor shower's 'radiant').

This year, the Perseids will peak on 11-13 August, but you can spot them anytime from around 17 July to 24 August. The meteors can be seen at any time of night, but the darker it is, the better your chances, so aim for between midnight and Sam. A night with little moonlight, around the new moon on 20 July or 19 August, would be perfect.

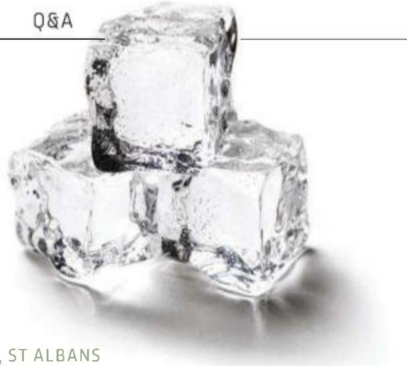
Let your eyes adjust, then look directly up. Although the meteors originate in Perseus, it's not important to specifically find that constellation – they can travel across the whole sky. So make sure you can see as much sky as possible, without obstruction from buildings or trees, to give yourself the best chance. Most importantly, make sure that you're comfortable, by taking a chair (a reclining one is best), a blanket, and maybe even a bottle of wine with you. **AB**

ALAMY X2, GETTY IMAGES X4, NASA ILLUSTRATIONS: DANIEL BRIGHT

GARETH SPENCER

WILL THERE EVER BE A ROBOT THAT DOES ALL THE HOUSEWORK?

We already have specialised robots for housework: washing machines and dishwashers, plus robotic vacuum cleaners and floor mops. In development, there's a laundry-folding robot called FoldiMate, which sucks in your clothes and spits them out in a neat pile; an automated ironing machine called Effie; and robotic chefs from Samsung and Moley Robotics. Offices in the US, meanwhile, can hire a toilet-cleaning robot, developed by Somatic. Sadly, combining all of these robots into one is just not possible with today's technology – you would need a robot with the dexterity of the human body and the adaptability of the human brain, and we're still many years away from that. ***PB***



KATIE W, ST ALBANS

WHY DO ICE CUBES CRACK WHEN YOU PUT THEM IN WATER?

Ice cubes typically have a temperature of around -18°C, while tap water is around 10°C. When the cubes are dropped in, the relative warmth makes their outer layers start to expand, while their cold inner layers remain unchanged. This creates tension between the layers which can tear the cube apart. Whether it does or not depends on the presence of 'defects' in the ice cubes, which are caused by uneven cooling and/or dissolved oxygen. These lead to the layers of ice being poorly connected to one another, and if the defects are big enough, they'll allow the internal tension to crack the whole ice cube apart. ***RM***

JAMES FOSTER

WHY DOES SNEEZING FEEL SO GOOD?

It's popularly claimed that a sneeze is equivalent to one-seventh of an orgasm. While we can certainly debate the exact fraction, there is a grain of truth to this. The relaxation after any intense muscle contraction is pleasurable because it triggers the release of feel-good chemicals called endorphins – try this for yourself by squeezing your stomach muscles really tightly. A sneeze is also a response to an 'itch', and scratching an itch always brings relief. ***LV***

CROWDSCIENCE

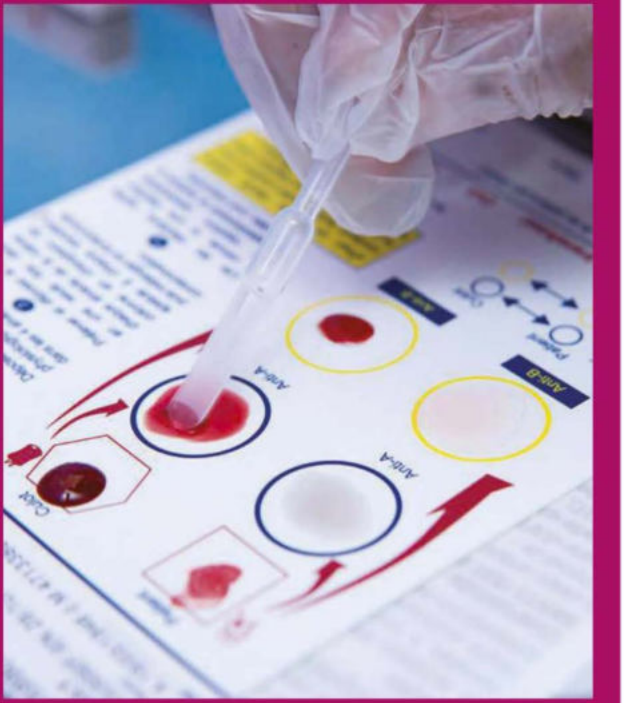
Every week on BBC World Service, *CrowdScience* answers listeners' questions on life, Earth and the Universe. Tune in every Friday evening on BBC World Service, or catch up online at **bbcworldservice.com/crowdscience**

WHY DO WE HAVE DIFFERENT BLOOD TYPES?

There are four main blood types: A, B, AB and O. The system for classifying them came about in order to allow safe blood transfusions. Like all cells, red blood cells have molecules on their surface called 'antigens'. People have different antigens, depending on their genes. We need to pay attention to red blood cell antigens because if you receive a transfusion from someone with different ones, your immune system will attack them, which can cause kidney failure and lung problems.

The Austrian doctor Karl Landsteiner identified the most common blood antigens in 1901, which he called A and B. He also found that some people had neither antigen (type O), and in 1902 two of his students discovered that some people have both antigens (type AB). In 1937, Landsteiner and his colleague Alexander Wiener discovered another antigen, which they called 'Rhesus factor' because of its similarity to an antigen in rhesus monkeys. If you have this antigen, now known as RhD, your blood is 'RhD positive'; if you don't, your blood is 'RhD negative'.

Since then, medics have found more ways of categorising blood types: there are currently 36 systems in total, involving 346 different antigens – most of which are extremely rare or don't have particular consequences for blood transfusions. The A and B antigens both evolved over 20 million years ago. Their exact purpose is unknown, but they may play a role in blood clotting and help to protect against certain diseases such as cholera. ***LV***



GETTY IMAGES X3, ALAMY ILLUSTRATION: DANIEL BRIGHT

6bn

The number of Earth-like planets that could exist in the Milky Way, according to new estimates from the University of British Columbia.

DILEEP BAGNALL, LANCASHIRE

WHAT HAPPENS TO MONEY TAKEN OUT OF CIRCULATION?

Every year, hundreds of millions of banknotes are returned to the Bank of England because they're old, damaged or dirty. Until around 30 years ago, the notes were incinerated – including at the Bank of England's London offices to help heat the building. But then the Bank of England introduced recycling, along with composting using methods similar to those used for food waste. Some banknotes continued to be incinerated, with the energy being recovered for electricity generation. The introduction of polymer banknotes in 2016 forced a rethink, as these aren't compostable. So now the Bank of England is switching to a new form of recycling, in which the notes are processed to make new plastic products like plant pots. ***RM***

QUESTION OF THE MONTH

WINNER

Holly wins a Logitech StreamCam, worth £139. Featuring pristine image quality, dual front-facing microphones, versatile mounting options, and USB-C connectivity, it's the perfect camera for broadcasting to your favourite streaming platforms. **logitech.com**

HOLLY GOODRICK, LONDON

IS IT POSSIBLE TO RECYCLE PLASTICS AN INFINITE NUMBER OF TIMES?

Plastics are made of polymers – long, repeating chains of atoms that are created by combining together building blocks called monomers. These monomers, which form the polymer's repeating 'unit', are shorter chains of atoms such as hydrogen, carbon and oxygen. During the manufacturing process, chemical additives such as pigments, fire retardants and antioxidants are also added, giving the plastic desirable characteristics like colour, heat resistance or durability.

Most plastic recycling plants shred plastic waste and melt it down before remoulding it. But this process means that the recycled plastic is weaker. This is because, firstly, the process breaks the polymers. And secondly, any impurities or additives in the plastic waste are virtually impossible to separate from the rest of the material. Recycled plastics are mixed with virgin material to make them usable, but even then, they can only usually be recycled two or three times before their quality becomes too poor for use. Glass and aluminium, on the other hand, don't degrade during the recycling process, so can be recycled endlessly.

To improve the recycling process, scientists are working on chemical methods that can return waste plastics to their original monomer state (a process called 'depolymerisation'). Part of the challenge lies in developing environmentally friendly enzymes and chemicals that can tease apart the plastic's monomers. Another area of research is looking into new types of plastic polymers that allow additives and other contaminants to be removed from them more easily. In time, these advances could mean that plastics (including some currently unrecyclable types) can be recycled again and again. ***AFC***

EMAIL YOUR QUESTIONS TO **QUESTIONS@SCIENCEFOCUS.COM** OR TWEET US **@SCIENCEFOCUSQA**

COVID-19 AFTER LOCKDOWN

WHAT YOU NEED TO KNOW

As the UK gradually comes out of lockdown, what do the coming months have in store?

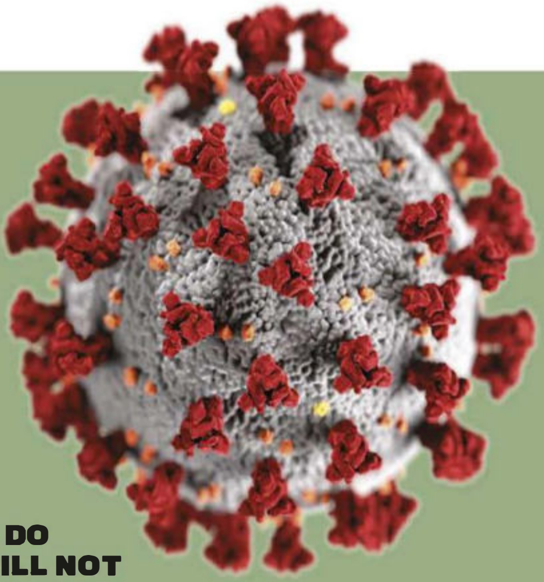
PRESS ASSOCIATION X2, GETTY IMAGES, US PUBLIC HEALTH IMAGE LIBRARY

WILL THERE BE A SECOND PEAK?

We will be facing COVID-19 for many months to come. We are still far from achieving herd immunity, where enough people have become infected (and therefore, it is hoped, immune) to halt the disease's spread. It is also likely that we won't have a vaccine for at least another 12 months. As a result, we run a constant risk of a second peak in cases, especially as we ease lockdown restrictions. The key is to keep down the reproduction number R, which measures how many people a single infected person will pass the disease to. At the peak of the UK outbreak, R was between 2 and 3. It has since dropped below 1, and will need to stay there if the virus is to be brought under control. Two things will help achieve this: personal precautionary measures (keeping physical distance, handwashing, wearing face coverings on public transport, avoiding crowded spaces), and public health interventions (testing, tracing and isolation). As long as these precautions are in place, we can prevent any new outbreaks from ripping through the population. The aim is to be able to ride a gentler ebb and flow of cases until we have a vaccine.

WILL THE VIRUS GET WORSE IN THE WINTER?

Many other respiratory viruses (such as the flu) are seasonal, with more cases seen in the colder winter months, so it's been suggested that the coronavirus SARS-CoV-2 could follow a similar pattern. There has been a drop-off in cases in the northern hemisphere as summer approaches, but this is likely to be due to the effectiveness of lockdown measures in many northern countries. It's possible that the weather does have a small effect: recent studies have shown that transmission of the virus decreases when the humidity increases (such as in the summer months). But, so far, the outbreak doesn't seem to be strongly tied to our seasons: the onset of the southern hemisphere winter, for example, has not caused increased transmission in Australia or New Zealand. So it looks like our individual and collective actions will play a much greater role in determining the trajectory of this pandemic.



WHAT DO WE STILL NOT UNDERSTAND ABOUT THE VIRUS?

Given that we only discovered this virus last December, our knowledge has advanced at an incredible pace. But there are still aspects of the virus that we don't understand. First, immunity. In order to achieve herd immunity, 60 to 70 per cent of the population would need to become immune, either through infection and recovery, or through vaccination. Both options rely on our bodies producing protective proteins called antibodies in response to the virus. The limited research at present says that infected people do generate antibodies, and that, in animals, the antibodies protect against the virus. However, we don't know if all people who are infected or vaccinated will be protected by their antibodies, and we don't know for how long protection will last. Second, we don't understand why the coronavirus has such varied effects in people, from no symptoms at all, to mild symptoms, to life-threatening illness. In some cases, this may be due to differences in ACE2 – an enzyme molecule that provides the entry point for the virus into our cells – but this is far from the whole story. And third, the virus is constantly mutating, but we don't know how much these mutations will affect its functioning. Some of the mutations we've already seen may have enabled the virus to spread better, but, so far, there's no evidence that it is getting more dangerous.

ARE THERE REASONS TO BE OPTIMISTIC?

It's a perfectly natural reaction to feel worried, anxious, sad or angry about this pandemic. It's affected the lives and livelihoods of billions. But there are reasons for hope. At the time of going to press, there are 32 vaccine candidates for COVID-19, with nine already in clinical trials. Initial results in human and animal studies are promising, with some vaccines showing good safety and effectiveness. We also now have a low-cost, readily-available drug, dexamethasone, which appears to significantly reduce the risk of death in COVID-19 patients who are on ventilators or on oxygen.

Slowly, life is moving back through the gears. Shops are opening, sports are returning, restrictions are being lifted. If there's one take-home message, it's that we are not at the mercy of this virus. In countries around the world, we are seeing that our collective actions can dramatically slow the spread of COVID-19. That's one thing to bear in mind as we start to return to 'normal' life.

WILL THINGS EVER GO BACK TO 'NORMAL'?

The 'new normal' has already become a cliché, but it's true that we're going to have to adjust to a new way of living for the foreseeable future. It's likely that there will be some form of physical distancing, as well as a clampdown on mass gatherings, until a vaccine is available. Factoring in the time for testing, manufacturing and distribution, this is likely at least 12 months away. In the meantime, governments will have to find the right balance between easing restrictions and protecting public health, while we do our bit as individuals by following the guidelines.

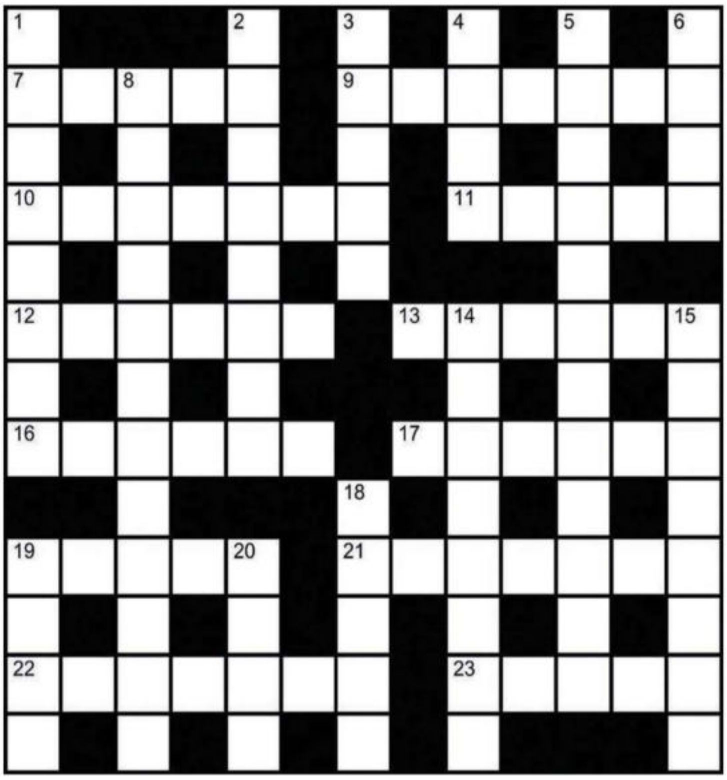
Protect Yourself & Others
WAIT HERE

by **DR JEREMY ROSSMAN**

Jeremy is a senior lecturer in virology at the University of Kent and the president of the non-profit organisation Research-Aid Networks.

CROSSWORD

GIVE YOUR BRAIN A WORKOUT



ACROSS

7 Call acidity level by number (5)

9 Foyer containing elderly bag (7)

10 Tenth month in the past, new shape (7)

11 Animal like this found in rubbish container (5)

12 Charge assembled in a sea (6)

13 Be economical, making small conservative terribly prim (6)

16 Extremely little time (6)

17 King and queen surround fellow in money (6)

19 Knock hospital for producing junk mail (5)

21 Port is more piquant (7)

22 Woman gets report on whole situation (7)

23 Sound disapproving, turning it on everyone playing (5)

DOWN

1 Saying I'm sharp is wrong, and getting old (8)

2 About dating eccentric star (3,5)

3 Opening feature at end of week (5)

4 Stick to association (4)

5 Timid stances about cinematic cliché (3,9)

6 Enthusiast has left a quiche (4)

8 Changing at once, less sensitive to anti-knock rating (6,6)

14 Firm, no tear involved, wearing a crown (8)

15 Picture the orientation of a page (8)

18 Gets a new place to perform (5)

19 Register a fish (4)

20 Laugh, getting a kiss for practical joke (4)

ANSWERS For the answers, visit **bit.ly/BBCFocusCW**
Please be aware the website address is case-sensitive.

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Groundbreaking new techniques to unlock the mysteries of the ocean.

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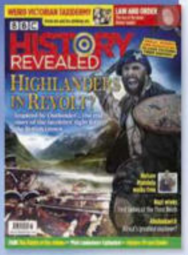

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A SCIENTIST'S GUIDE TO LIFE

HOW TO GARDEN FOR WILDLIFE

WE CAN ALL DO OUR BIT TO HELP BOOST BIODIVERSITY. BIOLOGIST **PROF DAVE GOULSON** EXPLAINS HOW TO WELCOME WILDLIFE INTO YOUR GARDEN

BUGS ARE IMPORTANT

They are food for other creatures, such as birds, bats and fish. They provide services, like recycling dead bodies, keeping the soil healthy, and pollinating. Three-quarters of the crops we eat rely on insect pollination. It's been said that if insects were to vanish, the environment would 'collapse into chaos'. I think that's true.

EVERYONE CAN DO SOMETHING

The UK has half a million hectares of garden. That's a bigger area than all of our nature reserves. It doesn't take much to make your patch more wildlife friendly.

PLANT THE RIGHT FLOWERS

Some flowers, like the classic tea rose, may be pretty, but don't offer much to pollinators. Old-fashioned cottage flowers and herbs, like catmint and comfrey, are much better. In my own garden, I have lots of wildflowers like bird's-foot trefoil, pink campion and teasels, mixed in with ornamental flowers.

PLANT FOR YEAR-ROUND COLOUR

Aim for continuity of flowering for as much of the year as you can, so that, for example, bumblebees have got food right through from when the queens come out in March to when the nests fizzle out in September. Try to cater for different insects. Bees with long tongues like flowers such as foxgloves and honeysuckle; short-tongued species prefer things like geraniums and cotoneasters.

GIVE THE MOWER A REST

Most lawns contain wildflowers like clovers and dandelions, but they never get the chance to bloom because they're constantly being mown down. These flowers are really good for pollinators. I'd love it if we could get people to move away from this idealised Wimbledon-style lawn to something more meadow-like.

MANY GARDEN CENTRES AREN'T THAT 'GREEN'

Bedding plants are reared in peat-based compost in disposable plastic pots and have almost certainly been sprayed with pesticides. We did some research recently and found that 75 per cent of plants being sold as 'bee-friendly' had insecticides in them, so you could be buying them and poisoning bees. To avoid this, buy from organic garden centres, grow from seed, or plant swap with neighbours. Plus, 90 per cent of garden composts contain peat. Peat comes from peat bogs, which are rare habitats with lots of wildlife. They're also big stores of carbon. It's frustrating, as alternatives are available.

DON'T DESPAIR IF YOU DON'T HAVE A GARDEN

If you have a balcony, then grow plants like marjoram and thyme in pots. Even in a city, the bees will sniff them out. You can still have a bee hotel. Or take part in community initiatives, like sowing wildflowers in public spaces. **SF**

PROF DAVE GOULSON

Dave is a biologist and bumblebee expert at the University of Sussex. His most recent book, The Garden Jungle *(£9.99, Vintage), is out now.*

Interviewed by Dr Helen Pilcher

NEED TO KNOW...

1

Be lazy – let plants go to seed to provide food for birds, and give the mower a rest to attract pollinators.

2

Old-fashioned cottage flowers and herbs are a magnet for insects.

3

Squeeze in a pond. Even an old basin sunk into the ground will attract dozens of species.

ILLUSTRATION: OVADIA BENISHU

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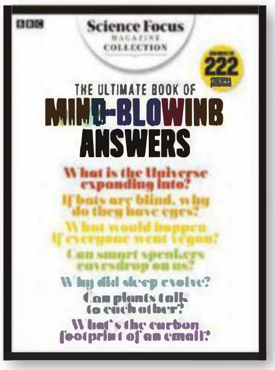
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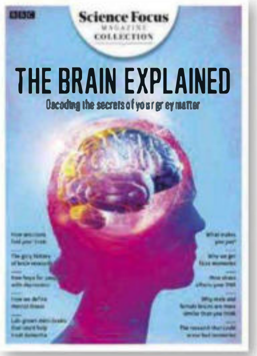
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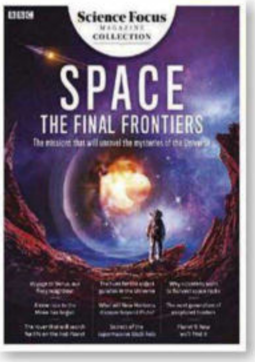
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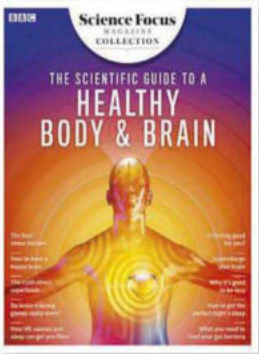
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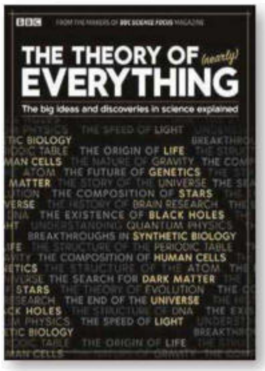
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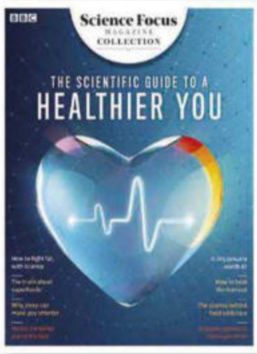
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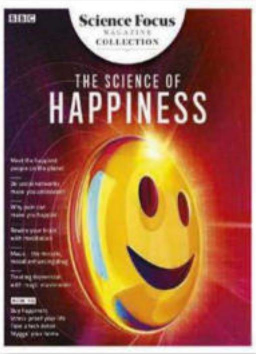
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Thank you, Sylvia

Sylvia left a gift in her Will to help conquer Stroke

The first we knew of Sylvia was when we received notification of the gift she'd left us in her Will. Shortly after, a beautiful story of a much-loved woman began to unfurl.

Friends remembered Sylvia's kind-heart and her wish to help others. She spent part of her adult-life caring for her mother, and developed a passion for medicine. Becoming a medical secretary was her next step and, in the course of her career, she discovered the devastating impact a stroke could have on people and their families. She saw that research and treatment were vastly under-funded, and she decided to remember the Stroke Association in her Will.

Sylvia's gift has helped fund our work to conquer stroke. She's supported research to prevent and treat stroke, and she's helped care for survivors. And that's something you can do too – in the same way.

If you would like to learn more about remembering the Stroke Association in your Will, please get in touch.

Call 020 75661505 email legacy@stroke.org.uk
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